The Christian Philosopher

Thomas Dick

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THE

CHRISTIAN PHILOSOPHER;

OR,

THE CONNECTION OF SCIENCE AND PHILOSOPHY WITH RELIGION.

BY

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Illustrated

WITH UPWARDS OF ONE HUNDRED AND FIFTY ENGRAVINGS.

TWENTY-FIFTH EDITION.

REVISED AND GREATLY ENLARGED.

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PREFACE TO THE TWENTY-FIRST EDITION.

In consequence of the progress of the Arts and Sciences since the first Editions of the following Work were published, and the liberal patronage bestowed upon it by the Public—it has been deemed expedient to make a thorough revision of the whole, so as to embrace the latest improvements and discoveries in the different departments to which its diversified subjects refer. The present Edition has accordingly been carefully revised in every portion of the Work, and very large additions made to its several departments; besides the introduction of nearly two hundred Woodcuts, illustrative of its multifarious subjects. The department of *Natural History* has been considerably enlarged, by various additional illustrations. The article Geology has been almost entirely re-written, and enlarged to more than triple its former extent. The department of Geography has been extended to more than double the space it formerly occupied. The articles Astronomy, Natural Philosophy, Chemistry, Physiology, History, Printing, Mariner's Compass, Telescope, Air Balloons, Steam Navigation, etc., have likewise been very considerably enlarged. To the former subjects are now added comprehensive sketches of the following recently discovered departments of Science and Art:—The Daguerreotype, Electrotype, Electro-Magnetism, Electric Telegraphs, Railroads,

ETC., besides a variety of paragraphs inserted in numerous places throughout the body of the Work. Descriptions of such objects as the following:—*Light*, *Cataracts*, *Winds*, *Luminous* and *Fiery Meteors*, *Coral Islands*, the *Phenomena* of *Solar Eclipses*, *Thunder Storms*, *etc.*, *etc.*, have likewise been introduced into their appropriate places, so as to present to the reader a view of some of the grandest and most interesting phenomena of nature.

BROUGHTY FERRY, near Dundee.
October, 1856.

PREFACE TO THE SECOND EDITION.

The following pages were written under the impression, that the visible manifestations of the attributes of the Deity are too frequently overlooked by Christians in their views of the great objects of Religion, and in the worship they offer to the Father of their spirits; and are intended to show, that the Teachers of Religion, in imparting instruction either to the old or to the young, ought to embrace a wider range of illustration, in reference to divine subjects, than that to which they are usually confined.

Throughout the whole of the discussions contained in this work, the Author has pursued his own train of thought; and in so doing, he trusts that he has been enabled to render some of his illustrations more interesting to the young and untutored mind, than if he had adhered rigidly to the sentiments of others, and to the technical language of science. The sketches of the different sciences are not mere extracts or compilations, but are, for the most part, original composition—in which it has been his main object to embody as many facts as his limits could permit,—in order to excite the enquiring mind to further investigations into the different departments of physical science.

It is presumed, that no Christian reader will for once imagine, that the views illustrated in this work are intended to be *substituted* in place of the peculiar revelations of the Bible. The object of the volume is to illustrate the harmony which subsists between the system of Nature and the system of Revelation; and to show, that the manifestations of God in the material universe ought to be blended with our views of the facts and doctrines recorded in the volume of Inspiration.

It is taken for granted, throughout the whole range of the following illustrations, that the Scriptures contain a Revelation from Heaven; and under a firm belief of this important truth, the Author has embellished his work with frequent quotations from the energetic and sublime language of this Sacred Book.

The Author has carefully revised every portion of the present Edition, and introduced a variety of corrections and modifications. He has likewise introduced additional matter, and also several illustrative engravings. In its present form, the Author trusts, that independently of the moral reflections it contains it will be found to comprise popular descriptions of a greater number of scientific facts than is to be found in any other volume of the same size.

Various topics, originally intended to be illustrated have been unavoidably omitted. Some of these are stated in the last paragraph of Chapter IV.—the illustration of which, in combination with other kindred topics, would fill a volume of the same size as the present. This subject (for which the Author has abundance of materials) will be prosecuted in another volume, under the title of 'THE PHILOSOPHY OF RELIGION,' and will comprise, among many other subjects of discussion, illustrations of the moral relation of intelligent beings to their Creator, and to one another—the physical and rational grounds of those moral laws which the Deity has promulgated—the views which science affords of the incessant energies of Creating power, and of the grand and multifarious objects over which divine providence presides—the relation of science to a future state, and of the aids which the discoveries of science afford, for enabling us to form a conception of the perpetual improvement of the celestial inhabitants in knowledge and felicity. These subjects will be illustrated by a variety of interesting details of facts, in relation to the system of nature, the history of nations, and the moral state of Christian and general society.

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THE

CHRISTIAN PHILOSOPHER.

INTRODUCTION.

On the subject of Religion, mankind have in all ages been prone to run into extremes. While some have been disposed to attach too much importance to the mere exertions of the human intellect, and to imagine that man, by the light of unassisted reason, is able to explore the path of true wisdom and happiness, the greater part of religionists, on the other hand, have been disposed to treat scientific knowledge, in its relation to religion, with a degree of indifference bordering upon contempt. Both these dispositions are equally foolish and preposterous. For he who exalts human reason as the only sure guide to wisdom and felicity, forgets that man in his present state is a *depraved* intelligence, and consequently liable to err; and that all those who have been left solely to its dictates have uniformly failed in attaining these desirable objects. During a period of more than 5800 years the greater part of the human race have been left solely to the guidance of their rational powers, in order to grope their way to the Temple of Knowledge and the Portals of Immortality; but what has been the result of all their anxious researches? Instead of acquiring correct notions of the great Author of their existence, and of the nature of that homage which is due to his perfections, "they have become vain in their imaginations, and their foolish hearts have been darkened. Professing themselves to be wise they have become fools; and have changed the glory of the incorruptible God into an image made like to corruptible man and to four-footed beasts and creeping things." Instead of acquiring correct views of the principles of moral action, and conducting themselves according to the eternal rules of rectitude, they have displayed the operation of the most

diabolical passions, indulged in continual warfare, and desolated the earth with rapine and horrid carnage; so that the history of the world presents to our view little more than a series of revolting details of the depravity of our species, and of the wrongs which one tribe of human beings has wilfully inflicted upon another.

This has been the case not only among a few uncultivated hordes on the coasts of Africa, in the plains of Tartary, and the wilds of America, but even among those nations which stood highest in the ranks of civilization and of science. The ancient Greeks and Romans, who boasted of their attainments in philosophy and their progress in the arts, entertained the most foolish, contradictory, and unworthy notions of the object of divine worship, of the requirements of religion, and of the eternal destiny of man. They adored a host of divinities characterized by impiety, fraud, injustice, falsehood, lewdness, treachery, revenge, murder, and every other vice which can debase the human mind, instead of offering a tribute of rational homage to that supreme Intelligence who made and who governs the universe. Even their priests and philosophers indulged in the most degrading and abominable practices, and entertained the most irrational notions in regard to the origin of the universe and the moral government of the world. Most of them denied a future state of retribution, and all of them had their doubts respecting the reality of an immortal existence; and as to the doctrine of a resurrection from the dead they never dreamed of such an event, and scouted the idea, when proposed to them, as the climax of absurdity. The glory to which their princes and generals aspired was to spread death and destruction among their fellow-men—to carry fire and sword, terror and dismay, and all the engines of destruction, through surrounding nations—to fill their fields with heaps of slain—to plunder the survivors of every earthly comfort, and to drag captive kings at their chariot-wheels; that they might enjoy the splendour and the honours of a triumph. What has been now stated with regard to the most enlightened nations of antiquity will equally apply to the present inhabitants of China, of Hindostan, of the Japanese islands, of the Birman empire, and of every other civilized nation on which the light of Revelation has never shone, with this additional consideration, that they have enjoyed an additional period of 1800 years for making further investiga-

tions; and are at this moment as far from the object of their pursuit as when they first commenced their researches; and not only so, but some of these nations in modern times have mingled with their abominable superstitions and idolatries many absurdities and horrid cruelties which were altogether unknown among the Greek and Roman population.

Such are the melancholy results to which men have been led, in the most interesting and important of all investigations, when left to the guidance of unassisted reason. They have wandered in the mazes of error and delusion; and their researches, instead of directing and expanding our religious views, have tended only to bewilder the human mind, and to throw a deeper shade of intellectual gloom over our apostate world. After a period of 6000 years has been spent in anxious enquiries after the path to true knowledge and happiness—ignorance, superstition, idolatry, vice, and misery, still continue to sway their sceptre over the great majority of the human race; and if we be allowed to reason from the past to the future, we may rest assured that while mankind are destitute of a Guide superior to the glimmerings of depraved reason, they would be no nearer the object of their pursuit after the lapse of 60,000 years than at the present moment. It is only in connection with the discoveries of Revelation that we can expect that the efforts of human reason and activity will be successful in abolishing the reign of ignorance and degrading superstition, in illuminating the benighted tribes of the pagan world, and in causing "righteousness and order and peace to spring forth before all the nations." Though the Christian religion has never yet been fully understood and recognized in all its aspects and bearings, nor its requirements been cordially complied with, by the great body of those who profess to believe in its divine origin, yet it is only in those nations who have acknowledged itsnauthority, and in some measure submitted to its dictates, that any thing approximating to just conceptions of the supreme Intelligence, and of his moral government, is found to prevail.

But, on the other hand, though the light of nature is of itself a feeble and insufficient guide to direct us in our views of the supreme Intelligence, and of our eternal destination, yet it is a most dangerous and delusive error to imagine that reason and the study of the material world ought to be discarded from the science of reli-

gion. The man who would discard from religion the efforts of the human intellect, and the science of Nature, forgets that he who is the Author of human redemption is also the Creator and Governor of the whole system of the material universe—that it is one end of that moral renovation which the Gospel effects, to qualify us for contemplating aright the displays of divine perfection which the works of creation exhibit—that the visible works of God are the principle medium by which he displays the attributes of his nature to intelligent beings—that the study and contemplation of these works employ the faculties of intelligences of a superior order[1]—that man, had he remained in primeval innocence, would have been chiefly employed in such contemplations—that it is one main design of divine Revelation to illustrate the operations of Providence, and the agency of God, in the formation and preservation of all things—and that the Scriptures are full of sublime descriptions of the visible creation, and of interesting references to the various objects which adorn the scenery of Nature. Without the cultivation of our reasoning powers, and an investigation of the laws and economy of Nature, we could not appreciate many of the excellent characters, the interesting aspects, and the sublime references of revealed religion; we should lose the full evidence of those arguments by which the existence of God and his attributes of wisdom and omnipotence are most powerfully demonstrated; we should remain destitute of these sublime conceptions of the perfections and agency of Jehovah which the grandeur and immensity of his works are calculated to inspire; we should never perceive, in its full force, the evidence of those proofs on which the divine authority of Revelation is founded; we could not give a rational interpretation of the spirit and meaning of many parts of the sacred oracles; nor could we comply with those positive commands of God which enjoin us to contemplate the wonders of his power, "to meditate on all his works, and to talk of all his doings."

Notwithstanding these and many other considerations which show the folly of overlooking the visible manifestations of Deity in the exercises of religion, it has long been the practice of certain theologians to depreciate the wonderful works of Jehovah, and to attempt to throw them into the shade, as if they were unworthy of

[1] Revelation, iv, 11; xv, 3, etc.

our serious contemplation. In their view, to be a bad philosopher is the surest way to become a good Christian, and to expand the views of the human mind is to endanger Christianity, and to render the design of religion abortive. They seem to consider it as a most noble triumph to the Christian cause, to degrade the material world, and to trample under foot not only the earth but the visible heavens, as an old, shattered, and corrupted fabric, which no longer demands our study and admiration. Their expressions, in a variety of instances, would lead us almost to conclude that they considered the economy of Nature as set in opposition to the economy of Redemption, and that it is not the same God that contrived the system of Nature who is also the "Author of eternal salvation to all them that obey him."

It is unquestionably both foolish and impious to overlook or to undervalue any of the modes by which the Divine Being has been pleased to make known his nature and perfections to mankind. Since he has given a display of his "Eternal power and Godhead" in the grand theatre of nature which forms the subject of scientific investigation, it was surely never intended, and would ill comport with reverence for its adorable Author, that such magnificent displays of his power, wisdom, and beneficence as the material universe exhibits should be treated by his intelligent offspring with indifference or neglect. It becomes us to contemplate with adoring gratitude every ray of our Creator's glory, whether as emanating from the light of Revelation, or as reflected from the scenery of nature around us, or as descending from those regions where stars unnumbered shine, and planets and comets run their solemn rounds. Instead of contrasting the one department of knowledge with the other, with a view of depreciating the science of nature, our duty is to derive from both as much information and instruction as they are calculated to afford; to mark the harmony of the revelations they respectively unfold; and to use the revelations of nature for the purpose of confirming and amplifying and carrying forward our views of the revelation contained in the sacred Scriptures.

With regard to the revelation derived from the sacred records, it has been imagined by some that it has little or no reference to the operations of the material system, and that therefore the study of the visible works of God can be of little importance in promoting religious knowledge and holy affections. In the sequel

of this volume I shall endeavour to show that this sentiment is extremely fallacious and destitute of foundation. But in the mean time, although it were taken for granted it would form no argument against the combination of science with religion. For it ought to be carefully remarked, that divine Revelation is chiefly intended to instruct us in the knowledge of those truths which interest us as subjects of the *moral administration* of the Governor of the world; or, in other words, as apostate creatures and as moral agents. Its grand object is to develope the openings and bearings of the plan of divine mercy; to counteract those evil propensities and passions which sin has introduced; to inculcate those holy principles and moral laws which tend to unite mankind in harmony and love; and to produce those amiable tempers and dispositions of mind which alone can fit us for enjoying happiness either in this world or in the world to come. For this reason doubtless it is that in the sacred volume the *moral* attributes of Deity are brought more prominently into view than his *natural* perfections; and that those special arrangements of his providence which regard the *moral* renovation of our species are particularly detailed; while the immense extent of his universal kingdom, the existence of other worlds, and their moral economy, are but slightly hinted at or vailed in obscurity. Of such a revelation we stood in need; and had it chiefly embraced subjects of a very different nature it would have failed in supplying the remedies requisite for correcting the disorders which sin has introduced among mankind.—But surely it was never intended, even in a religious point of view, that the powers of the human mind, in their contemplations and researches, should be bounded by the range of subjects comprised in that revelation which is purely or chiefly of a *moral* nature; since the Divine Being has exhibited so magnificent a spectacle in the universe around us, and endowed us with faculties adequate to the survey of a considerable portion of its structure, and capable of deducing from it the most noble and sublime results. To walk in the midst of this "wide-extended theatre," and to overlook or to gaze with indifference on those striking marks of divine omnipotence and skill which every where appear, is to overlook the Creator himself, and to contemn the most illustrious displays he has given of his eternal power and glory. That man's religious devotions are much to be suspected, whatever show of piety he

may affect, who, in attempting to form some adequate conceptions of the object of his worship, derives no assistance from the sublime discoveries of astronomical science; from these myriads of suns and systems which form but a small portion of the Creator's immense empire![1] The professing Christian whose devotional exercises are not invigorated and whose conceptions of Deity are not expanded by a contemplation of the magnitude and variety of his works may be considered as equally a stranger to the more elevated trains of piety, and to the noble emotions excited by a perception of the beautiful and the sublime.

"The works of the Lord," says an inspired writer, "are *great*, and are sought out by all those who have pleasure therein." They all bear the stamp of infinite perfection, and serve as so many sensible mediums to exalt and expand our conceptions of Him whose invisible glories they represent and shadow forth. When contemplated in connection with the prospects opened by divine revelation, they tend to excite the most ardent desires after that state of enlarged vision where the plans and operations of Deity will be more clearly unfolded, and to prepare us for bearing a part in the immortal hymn of the church triumphant:—"Great and marvellous are thy works, Lord God Almighty; just and true are thy ways, thou King of saints." The most illustrious characters that in all ages have adorned our race have been struck with the beauty and magnificence of the visible creation, and have devoted a certain portion of their time and attention in investigating its admirable economy and arrangement; and there can be no question that a portion of our thoughts devoted to the study of the wondrous works of the Most High must ultimately be conducive to the improvement of our intellectual powers, to our advancement in the Christian life, and to our preparation for the exalted employments of the eternal world.

In fine, since the researches of modern times have greatly enlarg-

[1] As some readers seem to have mistaken the Author's meaning in this and similar passages, it may be proper to state that his meaning is not—that a knowledge of natural science is *essential* to genuine piety; but that the person *who has an opportunity of making himself acquainted with the science of nature*, and of contemplating the wonders of the heavens in their true light, and who does not find his views of the Creator expanded and his religious emotions elevated by such studies, has reason to call in question the nature and the sincerity of his devotional feelings.

ed our views of the system of universal nature, and of the vast extent to which the operations of the Creator are carried on in the distant regions of space,—since the late discoveries of naturalists and experimental philosophers, with respect to the constituent parts of the atmosphere, water, light, heat, the gases, the electric, galvanic, and magnetic fluids, and the economy and instincts of animated beings, have opened to our view a bright display of divine wisdom in the contrivance and arrangement of the different parts of our terrestrial habitation,—since improvements in the useful arts have kept pace with the progress of science, and have been applied to many beneficial purposes, which have ultimately a bearing on the interests and the progress of religion,— since a general desire to propagate the truths of Christianity in heathen lands now animates the mass of the religious world,—since the nations of both continents are now aroused to burst asunder the shackles of despotism, and to enquire after rational liberty and mental improvement,—and since all these discoveries, inventions, and movements, and the energies of the human mind from which they spring, are under the control and direction of that omnipotent Being who made and who governs the world,—they ought to be considered as parts of those providential arrangements in the progress of which He will ultimately accomplish the illumination of our benighted race, and make the cause of righteousness and truth to triumph among all nations. And therefore the enlightened Christian ought thankfully to appreciate every exhibition and every discovery by which his conceptions of the attributes of God, and of the grandeur of his works may be directed and enlarged, in order that he may be qualified to "speak of the honour of his majesty, and talk of his power; to make known to the sons of men his mighty acts, and the glorious majesty of his kingdom."

CHAPTER I.

OF THE NATURAL ATTRIBUTES OF THE DEITY, WITH PARTICULAR ILLUSTRATIONS OF HIS OMNIPOTENCE AND WISDOM.

SECTION I.

ON THE RELATION OF THE NATURAL ATTRIBUTES OF DEITY TO RELIGION.

A FIRM conviction of the existence of God, and a competent knowledge of his natural perfections, lie at the foundation of all religion both natural and revealed. In proportion as our views of the perfections of Deity are limited and obscure, in a similar proportion will be our conceptions of all the relations in which he stands to his creatures, of every part of his providential procedure, and of all the doctrines and requirements of revealed religion.

By the natural or the essential attributes of God we understand such perfections as the following:—His eternity, omnipresence, infinite knowledge, infinite wisdom, omnipotence, and boundless beneficence. These are the characters and attributes of Deity which, we must suppose, form the chief subjects of contemplation to angels and to all other pure intelligencies; and in investigating the displays of which the sons of Adam would have been chiefly employed had they continued in primeval innocence. These attributes form the groundwork of all those gracious relations in which the God of salvation stands to his redeemed people in the economy of redemption; they lie at the foundation of the whole Christian superstructure; and were they not recognized as the corner stones of that sacred edifice, the whole system of the Scripture revelation would remain a baseless fabric. The full display of these perfections will be exhibited in the future world; the contemplation of this display will form one of the sublime employments "of

the saints in light;" and to prepare us for engaging in such noble exercises is one of the chief designs of the salvation proclaimed in the Gospel.

The Christian Revelation ought not to be considered as superseding the religion of Nature, but as carrying it forward to perfection. It introduces the Deity to us under *new* relations corresponding to the degraded state into which we have fallen. It is superadded to our natural relations to God, and takes it for granted that these natural relations must for ever subsist. It is true indeed that the essential attributes of God, and the principles of natural religion, cannot be fully discovered without the light of Revelation, as appears from the past experience of mankind in every generation; but it is equally true that when discovered by the aid of this celestial light they are of the utmost importance in the Christian system, and are as essentially connected with it as the foundation of a building is with the superstructure. Many professed Christians however seem to think and to act as if the Christian revelation had annulled the natural relations which subsist between man and the Deity; and hence the zealous outcry against every discussion from the pulpit that has not a *Direct* relation to what are termed the doctrines of grace. But nothing surely can be more absurd than to carry out such a principle to all its legitimate consequences. Can God ever cease to be omnipotent, or can man ever cease to be dependent for existence on his infinite power? Can the Divine Being ever cease to be omnipresent and omniscient, or can man ever cease to be the object of his knowledge and superintendence? Can infinite wisdom ever be detached from the Almighty, or can man ever be in a situation where he will not experience the effects of his wise arrangements? Can goodness ever fail of being an attribute of Jehovah, or can any sentient or intelligent beings exist that do not experience the effects of his bounty? Can divine benevolence ever cease in its operations throughout any period of future duration, or can any intelligent beings exist, throughout any department of creation, who shall not, in a greater or less degree, experience its effects? In short, can the relation of *creature* and *Creator* ever cease between the human race in whatever moral or physical situation they may be placed, and that almighty Being "who giveth to all life and breath and all things!" If none of these things can possibly happen, then the relations to which we refer must be eternal

and unchangeable, and must form the basis of all the other relations in which we can possibly stand to the Divine Being, either as apostate or as redeemed creatures; and therefore they ought to be exhibited as subjects for our frequent and serious contemplation as religious and moral agents. But, unless we make such topics a distinct subject of attention, and endeavour to acquire clear and comprehensive conceptions of our natural relations to God, we can never form a clear conception of those new and interesting relations into which we have been brought by the mediation of Jesus Christ.

If man had continued in his primitive state of integrity, he would have been for ever exercised in tracing the power, the beneficence, and other attributes of Deity, in the visible creation alone. Now that his fallen state has rendered additional revelations necessary, in order to secure his happiness, is he completely to throw aside those contemplations and exercises which constituted his chief employment while he remained a pure moral intelligence? Surely not. One great end of his moral renovation, by means of the Gospel, must be to enable him *to resume his primitive exercises*, and to qualify him for more enlarged views and contemplations of a similar nature, in that future world where the physical and moral impediments which now obstruct his progress will be completely removed.

It appears highly unreasonable, and indicates a selfish disposition of mind, to magnify one class of the Divine attributes at the expense of another; to extol, for example, the mercy of God, and neglect to celebrate his power and wisdom—those glorious perfections the display of which at the formation of our globe excited the rapture and admiration of angels and of innocent men. All the attributes of God are *equal*, because all of them are *infinite*, and therefore to talk of *darling* attributes in the Divine nature, as some have done, is inconsistent with reason, unwarranted by Scripture, and tends to exhibit a distorted view of the Divine character. The Divine mercy ought to be celebrated with rapture by every individual of our fallen race; but with no less rapture should we extol the Divine omnipotence; for the designs of mercy cannot be accomplished without the intervention of infinite power. Even the attribute of *justice*—which is frequently viewed with emotions of terror—is nothing else than a branch of the Divine benevolence, for preventing the inroads of anarchy and confusion, and for secur-

ing the order and happiness of the intelligent creation. All that we hope for in consequence of the promises of God, and of the redemption accomplished by Jesus Christ, must be founded on the conception we form of the operations of omnipotence. An example or two may not be unnecessary for illustrating this position.

We are warranted by the sacred oracles, to entertain the hope that these mortal bodies of ours, after they have mouldered in the dust, been dissolved into their primary elementary parts, and become the prey of devouring reptiles, during a lapse of generations or of centuries—shall spring forth from the tomb to new life and beauty, and be arrayed in more glorious forms than they now wear; yea, that all the inhabitants of our globe, from Adam to the end of time, though the bodies of thousands of them have been devoured by cannibals, have become the food of fishes and of beasts of prey, and have been burned to cinders, and their ashes scattered by the winds, over the different regions of sea and land—shall again be animated by the voice of the Son of God, and shall appear, each in his own proper person and identical body, before God the Judge of all. Now, the firmness of our hope of so astonishing an event, which seems to contradict all experience, and appears involved in such a mass of difficulties and apparent contradictions, must be in proportion to the sentiments we entertain of the divine intelligence, Wisdom, and Omnipotence. And where are we to find the most striking visible displays of these perfections except in the actual operations of the Creator within the range of our view in the material world?

Again, we are informed in the same divine records, that at some future period the earth on which we now dwell shall be wrapt up in devouring flames, and its present form and constitution for ever destroyed; that its redeemed inhabitants, after being released from the grave, shall be transported to a more glorious region; and that "new heavens and a new earth shall appear, wherein dwelleth righteousness." The Divine mercy having given to the faithful the promise of these astonishing revolutions and most magnificent events, our hopes of their being fully realized must rest on the infinite wisdom and omnipotence of Jehovah; and consequently, if our views of these perfections be limited and obscure, our hope in relation to our future destiny will be proportionably feeble and

languid; and will scarcely perform its office "as an anchor to the soul, both sure and stedfast." It is not merely by telling a person that God is all-wise and all-powerful that a full conviction of the accomplishment of such grand events will be produced. He must be made to see with his own eyes what the Almighty *has already done* and what he is now doing in all the regions of universal nature which lie open to our inspection; and this cannot be effected without directing his contemplations to those displays of intelligence and power which are exhibited in the structure, the economy, and the revolutions of the material world.

If the propriety of these sentiments be admitted it will follow, that the more we are accustomed to contemplate the wonders of Divine intelligence and power in the objects with which we are surrounded, the more deeply shall we be impressed with a conviction and a confident hope, that all the purposes of Divine mercy will ultimately be accomplished in our eternal felicity. It will also follow, that in proportion as the mind acquires a clear, an extensive, and a reverential view of the essential attributes of the Deity, and of those truths in connection with them which are objects of contemplation common to all holy beings, in a similar proportion will it be impressed and its attention arrested by every other divine subject connected with them. And it is doubtless owing to the want of such clear and impressive conceptions of the essential character of Jehovah, and of the first truths of religion, that the bulk of mankind are so little impressed and influenced by the leading doctrines and duties connected with the plan of the Gospel salvation, and that they entertain so many vague and untenable notions respecting the character and the objects of a superintending Providence. How often, for example, have we witnessed expressions of the foolish and limited notions which are frequently entertained respecting the operations of Omnipotence! When it has been asserted that the earth, with its load of continents and oceans, is in rapid motion through the voids of space—that the sun is 1,000,000 times larger than the terraqueous globe, and that millions of such globes are dispersed throughout the immensity of nature, —some who have viewed themselves as enlightened Christians have exclaimed at the impossibility of such facts, as if they were beyond the limits of divine power, and as if such representations were intended to turn away the mind from God and religion; while,

at the same time, they have yielded a firm assent to all the vulgar notions respecting omens, apparitions, and hobgoblins, and to the supposed extraordinary powers of the professors of divination and witchcraft. How can such persons assent, with intelligence and rational conviction, to the dictates of Revelation respecting the energies of Omnipotence which will be exerted at "the consummation of all things," and in those arrangements which are to succeed the dissolution of our sublunary system! A firm belief in the almighty power and unsearchable wisdom of God, as displayed in the constitution and movements of the material world, is of the utmost importance to confirm our faith and enliven our hopes of such grand and interesting events.

Notwithstanding the considerations now stated, which plainly evince the connection of the natural perfections of God with the objects of the Christian Revelation, it appears somewhat strange that, when certain religious instructors happen to come in contact with this topic they seem as if they were beginning to tread upon forbidden ground; and as if it were unsuitable to their office, as Christian teachers, to bring forward the stupendous works of the Almighty to illustrate his nature and attributes. Instead of expatiating on the numerous sources of illustration of which the subject admits, till the minds of their hearers are thoroughly affected with a view of the essential glory of Jehovah, they despatch the subject with two or three vague propositions, which, though logically true, make no impressions upon the heart; as if they believed that such contemplations were suited only to carnal men and mere philosophers; and as if they were afraid that the sanctity of the pulpit should be polluted by particular descriptions of those operations of the Deity which are perceived through the medium of the corporeal senses. We do not mean to insinuate that the essential attributes of God, and the illustrations of them derived from the material world, should form the sole or the chief topics of discussion in the business of religious instruction; but if the Scriptures frequently direct our attention to these subjects—if they lie at the foundation of all accurate and extensive views of the Christian Revelation—if they be the chief subjects of contemplation to angels and all other pure intelligencies in every region of the universe—and if they have a tendency to expand the minds of professed Christians, to correct their vague and erroneous conceptions,

and to promote their conformity to the moral character of God—we cannot find out the shadow of a reason why such topics should be almost if not altogether overlooked in the writings and the discourses of those who profess to instruct mankind in the knowledge of God and the duties of his worship.

We are informed by our Saviour himself that "this is life eternal, to know thee, the living and true God," as well as "Jesus Christ whom he hath sent." The knowledge of God in the sense here intended must include in it the knowledge of the natural and essential attributes of the Deity, or those properties of his nature by which he is distinguished from "all the idols of the nations." Such are his self-existence, his all-perfect knowledge, his omnipresence, his infinite wisdom, his boundless goodness, and almighty power—attributes which, as we have just now seen, lie at the foundation of all the other characters and relations of Deity revealed in the Scriptures. The acquisition of just and comprehensive conceptions of those perfections must therefore lie at the foundation of all profound veneration of the Divine Being, and of all that is valuable in religion. Destitute of such conceptions, we can neither feel that habitual *humility* and that *reverence* of the majesty of Jehovah which his essential glory is calculated to inspire, nor pay him that tribute of adoration and gratitude which is due to his name. Devoid of such views, we cannot exercise that cordial acquiescence in the plan of his redemption, in the arrangements of his providence, and in the requirements of his law, which the Scriptures enjoin. Yet how often do we find persons who pretend to speculate about the mysteries of the Gospel, displaying by their flippancy of speech respecting the eternal counsels of the Majesty of heaven—by their dogmatical assertions respecting the Divine character and the dispensations of Providence—and by their pertinacious opinions respecting the laws by which God *must* regulate his own actions—that they have never felt impressive emotions of the grandeur of that Being whose "operations are unsearchable and his ways past finding out!" Though they do not call in question his immensity and power, his wisdom and goodness, as so many abstract properties of his nature, yet the unbecoming familiarity with which they approach this august Being and talk about him, shows that they have never associated in their minds the stupendous displays of these perfections which have been given in

the works of his hands; and that their religion (if it may be so called) consists merely in a farrago of abstract opinions, or an empty name.

If then it be admitted that it is essentially requisite, as the foundation of religion, to have the mind deeply impressed with a clear and comprehensive view of the natural perfections of the Deity, it will follow that the ministers of religion, and all others whose province it is to communicate religious instruction, ought frequently to dwell with particularity on those proofs and illustrations which tend to convey the most definite and impressive conceptions of the glory of that Being whom we profess to adore. But from what sources are such illustrations to be derived? Is it from abstract reasonings and metaphysical distinctions and definitions, or from a survey of those objects and movements which lie open to the inspection of every observer? There can be no difficulty in coming to a decision on this point. We might affirm with the schoolmen, that "God is a Being whose centre is every where and his circumference nowhere;" that "he comprehends infinite duration in every moment;" and that "infinite space may be considered as the *sensorium* of the Godhead;" but such fanciful illustrations, when strictly analyzed, will be found to consist merely of *words* without *ideas*. We might also affirm with truth that God is a Being of infinite perfection, glory, and blessedness—that he is without all bounds or limits, either actual or possible—that he is possessed of power sufficient to perform all things which do not imply a contradiction—that he is independent and self-sufficient—that his wisdom is unerring, and that he infinitely exceeds all other beings. But these and other expressions of a similar kind are *merely technical terms*, which convey no adequate nor even tolerable notion of what they import. Beings constituted like man, whose rational spirits are connected with an organical structure, and who derive all their knowledge through the medium of corporeal organs, can derive their clearest and most affecting notions of the Divinity chiefly through the same medium; namely, by contemplating the *effects* of his perfections as displayed through the ample range of the visible creation. And to this source of illustration the inspired writers uniformly direct our views: "Lift up your eyes on high, and behold! who hath created these orbs? who bringeth forth their host by number, and calleth them all by their names? The

everlasting God, the Lord, by the greatness of his might, for that he is strong in power."—"He hath made the earth by his power; he hath established the world by his wisdom; he hath stretched out the heavens by his understanding." These writers do not perplex our minds by a multitude of technical terms and subtile reasonings; but lead us directly to the source whence our most ample conceptions of Deity are to be derived, that, from a steady and enlightened contemplation of the effects, we may learn the greatness of the Cause; and their example in this respect ought doubtless to be a pattern for every religious instructor.

SECTION II.

ILLUSTRATIONS OF THE OMNIPOTENCE OF THE DEITY.

In order to elucidate more distinctly what has now been stated, I shall select a few illustrations of some of the natural attributes of the Deity. And in the first place I shall offer a few considerations which have a tendency to direct and to amplify our conceptions of divine power.

Omnipotence is that attribute of the Divine Being by which he can accomplish every thing that does not imply a contradiction, however far it may transcend the comprehension of finite minds. By his power the vast system of universal nature was called from nothing into existence, and is continually supported in all its movements from age to age. In elucidating this perfection of God, we might derive some striking illustrations from the records of his dispensations towards man in the early ages of the world—when he overwhelmed the earth with a deluge which covered the tops of the highest mountains, and swept the crowded population of the ancient world into a watery grave—when he demolished Sodom and Gomorrah and the cities around them with fire from heaven —when he slew all the first-born of Egypt and turned their rivers into blood—when he divided the Red sea and the waters of Jordan before the tribes of Israel—when he made the earth open its jaws and swallow up Korah and all his company—and when he caused mount Sinai to smoke and tremble at his presence. But these and similar events, however awful, astonishing, and worthy of remembrance, were only *transitory* exertions of Divine power,

and are not calculated, and were never intended to impress the mind in so powerful a manner as those displays of omnipotence which are exhibited in the ordinary movements of the material universe. We have no hesitation in asserting that, with regard to this attribute of the Divinity, there is a more grand and impressive display in the works of Nature than in all the events recorded in the sacred history. Nor ought this remark to be considered as throwing the least reflection on the fulness and sufficiency of the Scripture revelation; for that revelation, as having a special reference to a *moral* economy, has for its object to give a more particular display of the *moral* than of the *natural* perfections of God. The miracles to which we have now referred, and every other supernatural fact recorded in the Bible, were not intended so much to display the *plenitude* of the power of the Deity as to bear testimony to the divine mission of particular messengers, and to confirm the truths they declared. It was not, for example, merely to display the energies of almighty power that the waters of the Red sea were dried up before the thousands of Israel, but to give a solemn and striking attestation to all concerned, that the most high God had taken this people under his peculiar protection; that he had appointed Moses as their leader and legislator; and that they were bound to receive and obey the statutes he delivered. The most appropriate and impressive illustrations of omnipotence are those which are taken from the *permanent* operations of Deity, which are visible every moment in the universe around us; or, in other words, those respecting *magnitude* and *motion* which are derived from the facts which have been observed in the material world.

In the first place, *the immense quantity of matter* contained in the universe presents a most striking display of almighty power.

In endeavouring to form a definite notion on this subject, the mind is bewildered in its conceptions, and is at a loss where to begin or to end its excursions. In order to form something approximating to a well defined idea, we must pursue a train of thought commencing with those magnitudes which the mind can easily grasp, proceeding through all the higher graduations of magnitude, and fixing the attention on every portion of the chain, till we arrive at the object or magnitude of which we wish to form a conception. We must endeavour, in the first place, to form a concep-

tion of the bulk of the world in which we dwell, which, though only a point in comparison of the whole material universe, is in reality a most astonishing magnitude, which the mind cannot grasp without a laborious effort. We can form some definite idea of those protuberant masses we denominate *hills*, which rise above the surface of our plains; but were we transported to the mountainous scenery of Switzerland, to the stupendous range of the Andes in South America, or to the Himalayan mountains in India, where masses of earth and rocks, in every variety of shape, extend several hundreds of miles in different directions, and rear their projecting summits beyond the region of the clouds, we should find some difficulty in forming an adequate conception of the objects of our contemplation. For, (to use the words of one who had been a spectator of such scenes,) "Amidst those trackless regions of intense silence and solitude, we cannot contemplate but with feelings of awe and admiration the enormous masses of variegated matter which lie around, beneath, and above us. The mind labours as it were to form a definite idea of those objects of oppressive grandeur, and feels unable to grasp the august objects which compose the surrounding scene." But what are all these mountainous masses, however variegated and sublime, when compared with the bulk of the whole earth? Were they hurled from their bases, and precipitated into the vast Pacific ocean, they would all disappear in a moment except perhaps a few projecting tops, which, like a number of small islands, might be seen rising a few fathoms above the surface of the waters.

The earth is a globe, whose diameter is nearly 8000 miles, and its circumference about 25,000, and consequently, its surface contains nearly 200,000,000 of square miles; a magnitude too great for the mind to take in at *one* conception. In order to form a tolerable conception of the whole, we must endeavour to take a leisurely survey of its different parts. Were we to take our sta-

tion on the top of a mountain, of a moderate size, and survey the surrounding landscape, we should perceive an extent of view stretching 40 miles in every direction, forming a circle 80 miles in diameter, and 250 in circumference, and comprehending an area of 5000 square miles. In such a situation, the terrestrial scene around and beneath us—consisting of hills and plains, towns and villages, rivers and lakes—would form one of the largest objects which the eye or even the imagination can steadily grasp at one time. But such an object, grand and extensive as it is, forms no more than the 40,000th part, of the terraqueous globe; so that, before we can acquire an adequate conception of the magnitude of our own world, we must conceive 40,000 landscapes of a similar extent to pass in review before us; and were a scene of the magnitude now stated to pass before us every hour, till all the diversified scenery of the earth were brought under our view, and were 12 hours a-day alloted for the observation, it would require 9 years and 48 days before the whole surface of the globe could be contemplated even in this general and *rapid* manner. But such a variety of successive landscapes passing before the eye, even although it were possible to be realized, would convey only a very vague and imperfect conception of the scenery of our world; for objects at the distance of forty miles cannot be distinctly perceived; the only view which would be satisfactory would be that which is comprehended within the range of three or four miles from the spectator.

Again, I have already stated, that the surface of the earth contains nearly 200,000,000 of square miles. Now, were a person to set out on a minute survey of the terraqueous globe, and to travel till he passed along every square mile on its surface, and to continue his route without intermission, at the rate of 30 miles every day, it would require 18,264 years before he could finish his tour, and complete the survey of "this huge rotundity on which we tread:" so that, had he commenced his excursion on the day on which Adam was created, and continued to the present hour, he would not have accomplished one third part of this vast tour.

In estimating the size and extent of the earth, we ought also to take into consideration the vast variety of objects with which it is diversified, and the numerous animated beings with which it is stored; the great divisions of land and water, the continents, seas,

and islands, into which it is distributed; the lofty ranges of mountains which rear their heads to the clouds; the unfathomable abysses of the ocean; its vast subterraneous caverns and burning mountains; and the lakes, rivers, and stately forests, with which it is so magnificently adorned;—the many millions of animals, of every size and form, from the elephant to the mite, which traverse its surface; the numerous tribes of fishes, from the enormous whale to the diminutive shrimp, which "play" in the mighty ocean; the aerial tribes which sport on the regions above us, and the vast mass of the surrounding atmosphere, which encloses the earth and all its inhabitants, as "with a swaddling band." The immense variety of beings with which our terrestrial habitation is furnished conspires, with every other consideration, to exalt our conceptions of that power by which our globe and all that it contains were brought into existence.

The preceding illustrations, however, exhibit the vast extent of the earth considered only as a mere superficies. But we know that the earth is a solid globe, whose specific gravity is nearly five times denser than water, or about twice as dense as the mass of earth and rocks which compose its surface. Though we cannot dig into its bowels beyond a mile in perpendicular depth, to explore its hidden wonders, yet we may easily conceive what a vast and indescribable mass of matter must be contained between the two opposite portions of its external circumference, reaching 8000 miles in every direction. The solid contents of this ponderous ball is no less than 263,858,149,120 cubical miles—a mass of material substance of which we can form but a very faint and imperfect conception: in proportion to which, all the lofty mountains which rise above its surface are less than a few grains of sand when compared with the largest artificial globe. Were the earth a hollow sphere, surrounded merely with an external shell of earth and water ten miles thick, its internal cavity would be sufficient to contain a quantity of materials 133 times greater than the whole mass of continents, islands, and oceans, on its surface, and the foundations on which they are supported. We have the strongest reasons, however, to conclude, that the earth in its general structure, is one solid mass, from the surface to the centre, excepting perhaps a few caverns scattered here and there amidst its subterraneous recesses; and that its density gradually increases from its

surface to its central regions. What an enormous mass of materials then is comprehended within the limits of that globe on which we tread! The mind labours, as it were, to comprehend the mighty idea, and, after all its exertion, feels itself unable to take in such an astonishing magnitude at *one* comprehensive grasp. How great must be the power of that Being who commanded it to spring from nothing into existence, who "measures the ocean in the hollow of his hand, who weigheth the mountains in scales, and hangeth the earth upon nothing!"

It is essentially requisite, before proceeding to the survey of objects and magnitudes of a superior order, that we should endeavour, by such a train of thought as the preceding, to form some tolerable and clear conception of the bulk of the globe we inhabit; for it is the only body we can use as a standard of comparison to guide the mind in its conceptions, when it roams abroad to other regions of material existence. And from what has been now stated, it appears that we have no *adequate* conception of a magnitude of so vast an extent; or at least, that the mind cannot, in any one instant, form to itself a distinct and comprehensive idea of it in any measure corresponding to the reality.

Hitherto then we have fixed only on a determinate magnitude —on a scale of a few inches, as it were, in order to assist us in our measurement and conception of magnitudes still more august and astonishing. When we contemplate by the light of science those magnificent globes which float around us in the concave of the sky, the earth, with all its sublime scenery, stupendous as it is, dwindles into an inconsiderable ball. If we pass from our globe to some of the other bodies of the planetary system, we shall find that one of these stupendous orbs is more than 900 times the size of our world, and encircled with a ring 200,000 miles in diameter, which would nearly reach from the earth to the moon, and would enclose within its vast circumference several hundreds of worlds as large as ours. Another of these planetary bodies, which appears to the vulgar eye only as a brilliant speck on the vault of heaven, is found to be of such a size that it would require 1400 globes of the bulk of the earth to form one equal to it in dimensions. The whole of the bodies which compose the Solar system (without taking the sun and the comets into account) contain a mass of matter 2500 times greater than that of the earth. The sun itself is 520

times larger than all the planetary globes taken together; and 1,300,000 times larger than the terraqueous globe. This is one of the most glorious and magnificent visible objects which either the eye or the imagination can contemplate; especially when we consider what perpetual and incomprehensible and powerful influence it exerts—what warmth and beauty and activity it diffuses, not only on the globe we inhabit but over the more extensive regions of surrounding worlds. Its energy extends to the utmost limits of the planetary system—to the planet Herschel which revolves at the distance of 1,800,000,000 of miles from its surface, and there it dispenses light and colour and comfort to all the beings connected with that far distant orb, and to all the moons which roll around it.

Here the imagination begins to be overpowered and bewildered in its conceptions of magnitude, when it has advanced scarcely a single step in its excursions through the material world. For it is highly probable, that all the matter contained within the limits of the Solar system, incomprehensible as its magnitude appears, bears a smaller proportion to the whole mass of the material universe than a single grain of sand to all the particles of matter contained in the body of the sun and his attending planets.

If we extend our views from the Solar system to the starry heavens, we have to penetrate, in our imagination, a space which the swiftest ball that was ever projected, though in perpetual motion, would not traverse in 1,000,000 years. In those trackless regions of immensity, we behold an assemblage of resplendent globes, similar to the sun in size and in glory, and doubtless accompanied with a retinue of worlds, revolving like our own around their attractive influence. The immense distance at which the nearest stars are known to be placed proves that they are bodies of a prodigious size, not inferior to our own sun, and that they shine not by reflected rays, but by their own native light. But bodies encircled with such refulgent splendour would be of little use in the economy of Jehovah's empire, unless surrounding worlds were cheered by their benign influence, and enlightened by their beams. Every star is therefore, with good reason, concluded to be a sun, no less spacious than ours, surrounded by a host of planetary globes, which revolve around it as a centre, and derive from it light and heat and comfort. Nearly 1000 of these luminaries may

be seen in a clear winter night by the naked eye; so that a mass of matter equal to 1000 solar systems, or to 1,320,000,000 of globes of the size of the earth may be perceived by every common observer in the canopy of heaven. But all the celestial orbs which are perceived by the unassisted sight do not form the 80,000th part of those which may be descried by the help of optical instruments. The telescope has enabled us to descry in certain spaces in the heavens thousands of stars where the naked eye could scarcely discern twenty. The late celebrated astronomer, Dr. Herschel, has informed us that in the most crowded parts of the Milky-way, when exploring that region with his best glasses, he has had fields of view which contained no less than 588 stars, and these were continued for many minutes; so that "in one quarter of an hour's time there passed no less than 116,000 stars through the field of view of his telescope."

It has been computed, that nearly 100,000,000 of stars might be perceived by the most perfect instruments were all the regions of the sky thoroughly explored; and yet all this vast assemblage of suns and worlds, when compared with what lies beyond the utmost boundaries of human vision, in the immeasurable spaces of creation may be no more than as the smallest particle of vapour to the immense ocean. Immeasurable regions of space lie beyond the utmost limits of mortal view, into which even imagination itself can scarcely penetrate, and which are doubtless replenished with the operations of Divine wisdom and omnipotence. For it cannot be supposed that a being so diminutive as man, whose stature scarcely exceeds six feet—who vanishes from the sight at the distance of a league—whose whole habitation is invisible from the nearest star—whose powers of vision are so imperfect, and whose mental faculties are so limited—it cannot be supposed that man who "dwells in tabernacles of clay, who is crushed before the moth," and chained down by the force of gravitation to the surface of a small planet, should be able to descry the utmost boundaries of the empire of Him who fills immensity, and dwells in "light unapproachable." That portion of his dominions, however, which lies within the range of our view presents such a scene of magnificence and grandeur as must fill the mind of every reflecting person with astonishment and reverence, and constrain him to exclaim, "Great is our Lord and of great power, his understanding is infin-

ite." "When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained; what is man that thou art mindful of him?" "I have heard of thee by the hearing of the ear;" I have listened to subtile disquisitions on thy character and perfections, and have been but little affected; "but now mine eye *seeth* thee: wherefore I humble myself, and repent in dust and ashes."

In order to feel the full force of the impression made by such contemplations, the mind must pause at every step in its excursions through the boundless regions of material existence; for it is not by a mere attention to the figures and numbers by which the magnitudes of the great bodies of the universe are expressed that we arrive at the most distinct and ample conceptions of objects so grand and overwhelming. The mind in its intellectual range must dwell on every individual scene it contemplates, and on the various objects of which it is composed. It must add scene to scene, magnitude to magnitude, and compare smaller objects with greater —a range of mountains with the whole earth, the whole earth with the planet Jupiter, Jupiter with the sun, the sun with a thousand stars, a thousand stars with 80,000,000, and 80,000,000 with all the boundless extent which lies beyond the limits of mortal vision; and, at every step of this mental process, sufficient time must be allowed for the imagination to expatiate on the objects before it, till the ideas approximate, as near as possible, to the reality. In order to form a comprehensive conception of the extent of the terraqueous globe, the mind must dwell on an extensive landscape, and the objects with which it is adorned: it must endeavour to survey the many thousands of diversified landscapes which the earth exhibits—the hills and plains, the lakes and rivers and mountains, which stretch in endless variety over its surface: it must dive into the vast caverns of the ocean—penetrate into the subterraneous regions of the globe, and wing its way, amidst clouds and tempests, through the surrounding atmosphere. It must next extend its flight through the more expansive regions of the Solar system—realizing, in imagination, those magnificent scenes which can be descried neither by the naked eye nor by the telescope; and comparing the extent of our sublunary world with the more magnificent globes that roll around us. Leaving the sun and all his attendant planets behind till they have diminished to the size of a

small twinkling star, it must next wing its way to the starry regions, and pass from one system of worlds to another, from one nebula[1] to another, from one region of nebulæ to another, till it arrive at the utmost boundaries of creation which human genius has explored. It must also endeavour to extend its flight beyond all that is visible by the best telescopes, and expatiate at large in that boundless expanse into which no human eye has yet penetrated, and which is doubtless replenished with other worlds, and systems, and firmaments, where the operations of infinite power and beneficence are displayed, in endless variety, throughout the illimitable regions of space.

Here then with reverence let us pause and wonder! Over all this vast assemblage of material existence God presides. Amidst the diversified objects and intelligencies it contains, he is eternally and essentially present. By his unerring wisdom all its complicated movements are directed. By his almighty fiat it emerged from nothing into existence, and is continually supported from age to age. "HE SPAKE AND IT WAS DONE; HE COMMANDED AND IT STOOD FAST." "By the word of the Lord were the heavens made, and all the host of them by the spirit of his mouth." What an astonishing display of divine power is here exhibited to our view! How far transcending all finite comprehension must be the energies of Him who only "spake and it was done;" who only gave the command, and this mighty system of the universe, with all its magnificence, started into being! The infinite ease with which this vast fabric was reared leads as irresistibly to conclude that there are powers and energies in the Divine mind which have never yet been exerted, and which may unfold themselves to intelligent beings, in the production of still more astonishing and magnificent effects, during an endless succession of existence. That man who is not impressed with a venerable and overwhelming sense of the power and majesty of Jehovah by such contemplations must have a mind incapable of ardent religious emotions, and unqualified for appreciating the grandeur of that Being "whose kingdom ruleth over all." And shall such ennobling views be completely withheld from a Christian audience? Shall it be considered as a matter of mere indifference whether their views of the Creator's works be limited to the sphere of a few miles around them, or extended to ten thousand worlds?—

[1] For an account of the *Nebulæ*, see ch. ii, Art. *Astronomy*.

whether they shall be left to view the operations of the Almighty throughout eternity past and to come, as confined to a small globe placed in the immensity of space, with a number of brilliant studs fixed in the arch of heaven, at a few miles' distance, or as extending through the boundless dimensions of space?—whether they shall be left to entertain no higher idea of the Divine Majesty then what may be due to one of the superior orders of the seraphim or cherubim; or whether they shall be directed to form the most august conceptions of the King eternal, immortal, and invisible, corresponding to the displays he has given of his glory in his visible works? If it be not, both reason and piety require that such illustrations of the Divine perfections should occasionally be exhibited to their view.

In the next place, the *rapid motions* of the great bodies of the universe, no less than their magnitudes, display the infinite power of the Creator.

We can acquire accurate ideas of the relative motions of moving bodies only by comparing the motions with which we are familiar with one another, and with those which lie beyond the general range of our minute inspection. We can acquire a pretty accurate conception of the velocity of a ship impelled by the wind—of a steam-boat—of a race-horse—of a bird darting through the air—of an arrow flying from a bow—and of the clouds when impelled by a stormy wind. The velocity of a ship is from 8 to 12 miles an hour; of a race-horse, from 20 to 30 miles; of a bird, say from 50 to 60 miles; and of the clouds, in a violent hurricane, from 80 to 100 miles an hour. The motion of a ball from a loaded cannon is incomparably swifter than any of the motions now stated: but of the velocity of such a body we have a less accurate idea, because its rapidity being so great we canot trace it distinctly by the eye through its whole range, from the mouth of the cannon to the object against which it is impelled. By experiments it has been found that its rate of motion is from 480 to 800 miles in an hour, but it is retarded every moment by the resistance of the air and the attraction of the earth. This velocity, however, great as it is, bears no sensible proportion to the rate of motion which is found among the celestial orbs. That such enormous masses of matter should move at all is wonderful; but when we consider the amazing velocity with which they are impelled, we are lost in astonishment.

The planet Jupiter, in describing its circuit round the sun, moves

at the rate of 29,000 miles an hour. The planet Venus, one of the nearest and most brilliant of the celestial bodies, and about the same size as the earth, is found to move through the spaces of the firmament at the rate of 80,000 miles an hour; and the planet Mercury, with a velocity of no less than 109,000 miles an hour, or 1830 miles in a minute—a motion 200 times swifter than that of a cannon ball.

These velocities will appear still more astonishing if we consider the magnitude of the bodies which are thus impelled, and the immense forces which are requisite to carry them along in their courses. However rapidly a ball flies from the mouth of a cannon, it is the flight of a body only a *few inches* in diameter; but one of the bodies whose motion has been just now stated, is 89,000 miles in diameter, and would comprehend within its vast circumference more than a thousand globes as large as the earth. Could we contemplate such motions from a fixed point, at the distance of only a few hundreds of miles from the bodies thus impelled, it would raise our admiration to its highest pitch, it would overwhelm all our faculties, and in our present state would produce an impression of awe and even of terror beyond the power of language to express. The earth contains a mass of matter equal in weight to at least 2,200,000,000,000,000,000,000, or more than two thousand trillions of tons, supposing its mean density to be only about 2½ times greater than water. To move this ponderous mass a single inch beyond its position, were it fixed in a quiescent state, would require a mechanical force almost beyond the power of numbers to express. The physical force of all the myriads of intelligencies within the bounds of the planetary system, though their powers were far superior to those of man, would be altogether inadequate to the production of such a motion. How much more must be the force requisite to impel it with a velocity 140 times swifter than a cannon ball, or 68,000 miles an hour, the actual rate of its motion in its course round the sun! But whatever degree of mechanical power would be requisite to produce such a stupendous effect, it would require a force 150 times greater to impel the planet Jupiter in its actual course through the heavens! Even the planet Saturn, one of the slowest moving bodies of our system, a globe 900 times larger than the earth, is impelled through the regions of space at the rate of 22,000 miles an hour,

GALILEO BEFORE THE CARDINALS.

carrying along with it two stupendous rings, and seven moons larger than ours, through its whole course round the central luminary. Were we placed within 1000 miles of this stupendous globe, (a station which superior beings may occasionally occupy,) where its hemisphere, encompassed by its magnificent rings, would fill the whole extent of our vision—the view of such a ponderous and glorious object, flying with such amazing velocity before us, would infinitely exceed every idea of grandeur we can derive from terrestrial scenes, and overwhelm our powers with astonishment and awe. Under such an emotion we could only exclaim, "GREAT AND MARVELLOUS ARE THY WORKS, LORD GOD ALMIGHTY!" The ideas of *strength* and *power* implied in the impulsion of such enormous masses of matter, through the illimitable tracts of space, are forced upon the mind with irresistible energy, far surpassing what any abstract propositions or reasonings can convey; and constrain us to exclaim, "Who is a strong Lord like unto thee! Thy right hand is become glorious in power! The Lord God omnipotent reigneth!"

If we consider the *immense number* of bodies thus impelled through the vast spaces of the universe—the rapidity with which the *comets*, when near the sun, are carried through the regions they traverse; if we consider the high probability, if not absolute certainty, that the sun, with all its attendant planets and comets, is impelled with a still greater degree of velocity towards some distant region of space, or around some wide circumference; that all the thousands of systems of that nebula to which the sun belongs are moving in a similar manner; that all the nebulæ in the heavens are moving around some magnificent central body; in short, that all the suns and worlds in the universe are in rapid and perpetual motion, as constituent portions of one grand and boundless empire, of which Jehovah is the Sovereign; and if we consider still further, that all these mighty movements have been going on, without intermission, during the course of many centuries, and some of them perhaps for myriads of ages before the foundation of our world was laid, it is impossible for the human mind to form any adequate idea of the stupendous forces which are in incessant operation throughout the unlimited empire of the Almighty. To estimate such mechanical force, even in a single instance, completely baffles the mathematician's skill, and sets the power of numbers at defiance. "Language" and figures and comparisons

are "lost in wonders so sublime," and the mind, overpowered with such reflections, is irresistibly led upwards to search for the cause in that OMNIPOTENT BEING who upholds the pillars of the universe —the thunder of whose power none can comprehend.

While contemplating such august objects, how emphatic and impressive appears the language of the sacred oracles: "Canst thou by searching find out God! Canst thou find out the Almighty unto perfection? Great things doth he which we cannot comprehend. Thine, O Lord, is the greatness and the glory and the majesty; for all that is in heaven and earth is thine. Among the gods there is none like unto thee, O Lord; neither are there any works like unto thy works. Thou art great, and dost wondrous things: thou art God alone. Hast thou not known, hast thou not heard, that the everlasting God, the Lord, the Creator of all things, fainteth not, neither is weary? there is no searching of his understanding. Let all the earth fear the Lord, let all the inhabitants of the world stand in awe of him; for he *spake* and *it was done;* he commanded and it stood fast.

Again the *immense spaces* which surround the heavenly bodies, and in which they perform their revolutions, tend to expand our conceptions on this subject, and to illustrate the magnificence of the Divine operations. In whatever point of view we contemplate the scenery of the heavens, an idea of grandeur irresistibly bursts upon the mind; and if empty space can, in any sense, be considered as an object of sublimity, nothing can fill the mind with a grander idea of magnitude and extension than the amplitude of the scale on which planetary systems are constructed. Around the body of the sun there is alloted a cubical space, 3,600,000,000 miles in diameter, in which 12 planetary globes revolve—every one being separated from another by intervals of many millions of miles. The space which surrounds the utmost limits of our system, extending, in every direction, to the nearest fixed stars, is at least 40,000,000,000,000, or forty billions of miles in diameter; and, it is highly probable, that every star is surrounded by a space of equal or even of greater extent. A body impelled with the greatest velocity which art can produce—a cannon ball, for instance—would require 20 years to pass through the space that intervenes between the earth and the sun, and 4,700,000 years ere it could reach the nearest star. Though the the stars seem to be

crowded together in clusters, and some of them almost to touch one another, yet the distance between any two stars which seem to make the nearest approach is such as neither words can express nor imagination fathom. These immense spaces are as unfathomable, on the one hand, as the magnitude of the bodies which move in them, and their prodigious velocities are incomprehensible, on the other; and they form a part of those magnificent proportions according to which the fabric of universal nature was arranged—all corresponding to the majesty of that infinite and incomprehensible Being "who measures the ocean in the hollow of his hand, and meteth out the heavens with a span." How wonderful that bodies at such prodigious distances should exert a mutual influence on one another! that the moon, at the distance of 240,000 miles, should raise tides in the ocean, and currents in the atmosphere! that the sun, at the distance of 95,000,000 miles, should raise the vapours, move the ocean, direct the course of the winds, fructify the earth, and distribute light and heat and colour through every region of the globe! yea, that its attractive influence and fructifying energy should extend even to the planet Herschel at the distance of 1,800,000,000 miles! So that in every point of view in which the universe is contemplated we perceive the same *grand scale* of operation by which the Almighty has arranged the provinces of his universal kingdom.

We would now ask in the name of all that is sacred, whether such magnificent manifestations of Deity ought to be considered as irrelevant in the business of religion, and whether they ought to be thrown completely into the shade in the discussions which take place on religious topics in "the assemblies of the saints!" If religion consist in the intellectual apprehension of the perfections of God, and in the moral effects produced by such an apprehension —if all the rays of glory emitted by the luminaries of heaven are only so many reflections of the grandeur of Him who dwells in light unapproachable—if they have a tendency to assist the mind in forming its conceptions of that ineffable Being whose uncreated glory cannot be directly contemplated—and if they are calculated to produce a sublime and awful impression on all created intelligencies,—shall we rest contented with a less glorious idea of God than his works are calculated to afford? Shall we disregard the works of the Lord, and contemn the operations of his hands," and

that too in the face of all the invitations on this subject addressed to us from heaven? For thus saith Jehovah—"Lift up your eyes on high, and behold, who hath created these things—who bringeth forth their host by number?—I the Lord, who maketh all things, who stretched forth the heavens alone, and spread abroad the earth by myself; all their host have I commanded." And if, at the command of God, we lift our eyes to the "firmament of his power," surely we ought to do it not with a "brute unconscious gaze," not with the vacant stare of a savage, not as if we were still enveloped with the mists and prejudices of the dark ages—but as surrounded by that blaze of light which modern science has thrown upon the scenery of the sky, in order that we may contemplate, with fixed attention, all that enlightened reason, aided by the nicest observations, has ascertained respecting the magnificence of the celestial orbs. To overlook the sublime discoveries of modern times, to despise them, or to call in question the reality as some religionists have done, because they bring to our ears such astonishing reports of the "eternal power" and majesty of Jehovah—is to act as if we were afraid lest the Deity should be represented as more grand and magnificent than he really is, and as if we would be better pleased to pay him a less share of homage and adoration than is due to his name.

Perhaps some may be disposed to insinuate that the views now stated are above the level of ordinary comprehension, and founded too much on scientific considerations, to be stated in detail to a common audience. To any insinuations of this kind it may be replied, that such illustrations as those to which we have referred are more easily comprehended than many of those abstract discussions to which they are frequently accustomed; since they are definite and tangible, being derived from those objects which strike the senses and the imagination. Any person of common understanding may be made to comprehend the leading ideas of extended space, magnitude and motion, which have been stated above, provided the description be sufficiently simple, clear, and well defined; and should they be at a loss to comprehend the principles on which the conclusions rest, or the mode by which the magnificence of the works of God has been ascertained, an occasional reference to such topics would excite them to enquiry and investigation, and to the exercise of their powers of observation and reasoning on such

subjects—which are too frequently directed to far less important objects.

The following illustration, however, stands clear of every objection of this kind, and is level to the comprehension of every man of common sense:—Either the earth moves round its axis once in 24 hours—or the sun, moon, planets, comets, stars, or the whole frame of the universe, move around the earth in the same time. There is no alternative, or third opinion, that can be formed on this point. If the earth revolve on its axis every 24 hours, to produce the alternative succession of day and night, the portions of its surface about the equator must move at the rate of more than 1000 miles an hour, since the earth is more than 24,000 miles in circumference. This view of the fact, when attentively considered, furnishes a most sublime and astonishing idea. That a globe of so vast dimensions, with all its load of mountains, continents, and oceans, comprising within its circumference a mass of 264,000,000,000 cubical miles, should whirl round with so amazing a velocity, gives us a most august and impressive conception of the greatness of that power which first set it in motion, and continues the rapid whirl from age to age! Though the huge masses of the Alpine mountains were in a moment detached from their foundations, carried aloft through the regions of the air, and tossed into the Mediterranean sea, it would convey no idea of a force equal to that which is every moment exerted, if the earth revolve on its axis. But should the motion of the earth be called in question, or denied, the idea of force or power will be indefinitely increased. For, in this case, it must necessarily be admitted that the heavens, with all the innumerable hosts of stars, have a diurnal motion around our globe; which motion must be inconceivably more rapid than that of the earth, on the supposition of its motion. For in proportion as the celestial bodies are distant from the earth, in the same proportion would be the rapidity of their movements. The sun, on this supposition, would move at the rate of 414,000 miles in a minute; the nearest stars at the rate of 1,400,000,000 of miles in a *second;* and the most distant luminaries, with a degree of swiftness which no numbers could express.[1] Such velocities, too, would be the rate of motion, not merely of a single globe like the earth, but of all the ten thousand times ten thousand spacious globes that exist

[1] See Appendix, Note I.

within the boundaries of creation. This view conveys an idea of power still more august and overwhelming than any of the views already stated, and we dare not presume to assert that such a degree of physical force is beyond the limits of infinite perfection: but on the supposition it existed, it would confound all our ideas of the wisdom and intelligence of the Divine mind, and would appear altogether inconsistent with the character which the Scriptures give us of the Deity as "the only-wise God." For it would exhibit a stupendous system of means altogether disproportioned to the end intended; namely, to produce the alternate succession of day and night to the inhabitants of our globe, which is more beautifully and harmoniously effected by a single rotation on its axis, as is the case with the other globes which compose the planetary system. Such considerations, however, show us that, on whatever hypothesis, whether on the vulgar or the scientific, or in whatever other point of view the frame of nature may be contemplated, the mind is irresistibly impressed with ideas of power, grandeur, and magnificence. And therefore, when an enquiring mind is directed to contemplate the works of God, on any hypothesis it may choose, it has a tendency to rouse reflection, and to stimulate the exercise of the moral and intellectual faculties, on objects which are worthy of the dignity of immortal minds.

We may now be, in some measure, prepared to decide, whether illustrations of the Omnipotence of the Deity, derived from the system of the material world, or those vague and metaphysical disquisitions which are generally given in theological systems, be most calculated to impress the mind, and to inspire it with reverence and adoration. The following is a description given of this attribute of God, by a well known systematic writer, who has generally been considered as a judicious and orthodox divine:—

"God is Almighty.[1] This will evidently appear in that, if he be infinite in all his other perfections he must be so in power; thus, if he be omniscient, he knows what is possible or expedient to be done; and if he be an infinite sovereign, he wills whatever shall come to pass. Now this knowledge would be insignificant, and his power inefficacious, were he not infinite in power, or almighty. Again, this might be argued from his justice, either in

[1] Revelation, i, 18; iv, 8.

rewarding or punishing; for, if he were not infinite in power, he could do neither of these, at least so far as to render him the object of that desire or fear, which is agreeable to the nature of these perfections; neither could infinite faithfulness accomplish all the promises which he hath made, so as to excite that trust and dependence, which is a part of religious worship; nor could he say without limitation, as he does, *I have spoken it, I will also bring it to pass: I have purposed it, I will also do it.*[1] But since power is visible in and demonstrated by its effects, and infinite power by those effects which cannot be produced by a creature, we may observe the almighty power of God in all his works, both of nature and grace; thus his eternal power is understood, as the apostle says, *by the things that are made;*[2] not that there was an eternal production of things, but the exerting this power in time proves it to be infinite and truly divine; for no creature can produce the smallest particle of matter out of nothing, much less furnish the various species of creatures with those endowments in which they excel one another, and set forth their Creator's glory. And the glory of his power is no less visible in the works of providence, whereby he upholds all things, disposes of them according to his pleasure, and brings about events which only he who has an almighty arm can effect."[3]

This is the whole that Dr. Ridgley judges it necessary to state in illustration of the attributes of omnipotence except what he says in relation to its operation in "the work of grace," in "the propagation and success of the Gospel," etc.; subjects to which the idea of power, or physical energy, does not properly apply. Such, however, are the meagre and abstract disquisitions generally given by most systematic writers. There is a continual play on the term infinite, which to most minds conveys no idea at all, unless it be associated with ample conceptions of motion, magnitude, and extension; and it is constantly applied to subjects to which it was never intended to apply, such as infinite faithfulness, infinite justice, infinite truth, etc.; an application of the term which is never sanctioned by Scripture, and which has a tendency to introduce confusion into our conceptions of the perfections of God. Granting that the statements and reasonings in such an extract as the above were unquestionable, yet what impression can they make upon the

[1] Isaiah xlvi, 11. [2] Romans i, 20. [3] Ridgley's Body of Divinity, p. 39.

mind? Would an ignorant person feel his conception of the Divinity much enlarged, or his moral powers aroused by such vague and general statements? And, if not, it appears somewhat unaccountable, that those sources of illustration, which would convey the most ample and definite views of the "eternal power" and glory of God, should be studiously concealed from the view. Vague descriptions and general views of any object will never be effectual in awakening the attention and arresting the faculties of the mind. The heart will always remain unimpressed, and the understanding will never be thoroughly excited in its exercise, unless the intellect have presented before it a well defined and interesting object, and be enabled to survey it in its various aspects; and this object must always have a relation to the material world, whether it be viewed in connection with religion or with any other subject.

Thus I have endeavoured, in the preceding sketches, to present a few detached illustrations of the Omnipotence and grandeur of the Deity, as displayed in the vast magnitude of the material universe—the stupendous velocities of the celestial bodies—and in the immeasurable regions of space which surround them, and in which their motions are performed. Such a magnificent spectacle as the fabric of the universe presents—so majestic, godlike, and overwhelming, to beings who dwell "in tabernacles of clay"—was surely never intended to be overlooked, or to be gazed at with indifference, by creatures endowed with reason and intelligence, and destined to an immortal existence. In forming a universe composed of so many immense systems and worlds, and replenished with such a variety of sensitive and intelligent existences, the Creator, doubtless, intended that it should make a sublime and reverential impression on the minds of all the intellectual beings to whom it might be displayed, and that it should convey some *palpable* idea of the infinite glories of his nature, in so far as material objects can be supposed to adumbrate the perfections of a spiritual and uncreated Essence. Dwelling in light inaccessible to mortals, and for ever vailed from the highest created being, by the pure spirituality and immensity of his nature, there is no conceivable mode by which the infinite grandeur of Deity could be exhibited to finite intelligencies, but through the medium of those magnificent operations which are incessantly going forward throughout

the boundless regions of space. Concealed from the gaze of all the "principalities and powers" in heaven, in the unfathomable depths of his essence, he displays his presence in the universe he has created, and the glory of his power, by launching magnificent worlds into existence, by adorning them with diversified splendours, by peopling them with various ranks of intelligent existence, and by impelling them in their movements through the illimitable tracts of creation.

It will readily be admitted by every enlightened Christian, that it must be a highly desirable attainment to acquire the most glorious idea of the Divine Being which the limited capacity of our minds is capable of receiving. This is one of the grand difficulties in religion. The idea of a Being purely IMMATERIAL, yet pervading infinite space, and possessed of no sensible qualities, confounds and bewilders the human intellect, so that its conceptions, on the one hand, are apt to verge towards extravagancy, while, on the other, they are apt to degenerate into something approaching to inanity. Mere abstract ideas and reasonings respecting infinity, eternity, and absolute perfection, however sublime we may conceive them to be, completely fail in arresting the understanding, and affecting the heart; our conceptions become vague, empty, and confused, for want of a material vehicle to give them order, stability, and expansion. Something of the nature of vast extension, of splendid and variegated objects, and of mighty movements, is absolutely necessary in order to convey to spirits dwelling in bodies of clay a definite conception of the invisible glories of the Eternal Mind; and therefore, in the immense variety of material existence with which the universe is adorned, we find every requisite assistance of this kind to direct and expand our views of the great object of our adoration. When the mind is perplexed and overwhelmed with its conception, when it labours, as it were, to form some well defined conceptions of an infinite Being, it here finds some tangible objects on which to fix, some sensible *substratum* for its thoughts to rest upon for a little, while it attempts to penetrate, in its excursions, into those distant regions which eye hath not seen, and to connect the whole of its mental survey with the energies of the "King eternal, immortal, and invisible."

To such a train of thought we are uniformly directed in the sacred oracles, where Jehovah is represented as describing himself

by the *effects* which his power and wisdom have produced:—"Israel shall be saved in the Lord with an everlasting salvation. For thus saith Jehovah that created the heavens; God himself that formed the earth and made it; he hath established it, he hath created it not in vain, he formed it to be inhabited; I am the Lord, and there is none else." "I have made the earth and created man upon it, my hands have stretched out the heavens, and all their hosts have I commanded." "Hearken unto me, O Israel: I am the first, I also am the last. Mine hand also hath laid the foundation of the earth, and my right hand hath spanned the heavens; when I call unto them, they stand up together. Who hath measured the waters in the hollow of his hand, and meted out heaven with a span, and weighed the mountains in scales? He who sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers; that stretcheth out the heavens as a curtain, that fainteth not, neither is weary." "The Lord made the heavens, the heaven of heavens, with all their hosts; honour and majesty are before him, and his kingdom ruleth over all."[1]—Such sublime descriptions of Jehovah, and references to his material works, are reiterated in every portion of the sacred volume: and the import and sublimity of such expressions cannot be fully appreciated unless we take into view all the magnificent objects which science has unvailed in the distant regions of creation.

This subject is calculated not merely to overpower the intellect with ideas of sublimity and grandeur, but also to produce a deep *moral* impression upon the heart; and a Christian philosopher would be deficient in his duty were he to overlook this tendency of the objects of his contemplation.

One important moral effect which this subject has a natural tendency to produce is profound HUMILITY. What an insignificant being does man appear, when he compares himself with the magnificence of creation, and with the myriads of exalted intelligencies with which it is peopled! What are all the honours and splendours of this earthly ball, of which mortals are so proud, when placed in competition with the resplendent glories of the skies! Such a display as the Almighty has given of himself, in the magnitude and variety of his works, was evidently intended "to stain the pride" of all human grandeur, that "no flesh should glory in

[1] Isaiah xlv, 17, 18, 22; xlviii, 12, 13; xl, 12, 22, etc.

his presence." Yet there is no disposition that appears so prominent among puny mortals as pride, ambition, and vain-glory—the very opposite of humility and of all those tempers which become those "who dwell in tabernacles of clay, and whose foundation is in the dust." Even without taking into account the state of man as a *depraved* intelligence, what is there in his situation that should inspire him with "lofty looks," and induce him to look down on his fellow-men with supercilious contempt? He derived his origin from the dust, he is allied with the beasts that perish, and he is fast hastening to the grave, where his carcase will become the food of noisome reptiles. He is every moment dependent on a superior being for every pulse that beats, and every breath he draws, and for all that he possesses; he is dependent even on the meanest of his species for his accommodations and comforts. He holds every enjoyment on the most precarious tenure; his friends may be snatched in a moment from his embrace; his riches may take to themselves wings and fly away; and his health and beauty may be blasted in an hour by a breath of wind. Hunger and thirst, cold and heat, poverty and disgrace, sorrow and disappointment, pain and disease, mingle themselves with all his pursuits and enjoyments. His knowledge is circumscribed within the narrowest limits, his errors and follies are glaring and innumerable; and he stands as an almost undistinguishable atom amidst the immensity of God's works. Still, with all these powerful inducements to the exercise of humility, man dares to be proud and arrogant.

> "Man, proud man,
> Dressed in a little brief authority,
> Plays such fantastic tricks before high heaven
> As make the angels weep."

How affecting to contemplate the warrior, flushed with diabolical pride, pursuing his conquests through heaps of slain, in order to obtain possession of a "poor pitiable speck of perishing earth;" exclaiming in his rage, "I will pursue, I will overtake, I will divide the spoil, my lust shall be satisfied upon them, I will draw the sword, my hand shall destroy them;" to behold the man of rank glorying in his wealth and his empty titles, and looking around upon the inferior order of his fellow-mortals as the worms of the dust; to behold the man of ambition pushing his way

through bribery and treachery and slaughter, to gain possession of a throne, that he may look down with proud pre-eminence upon his fellows; to behold the haughty airs of the noble dame, inflated with the idea of her beauty and her high birth, as she struts along surveying the ignoble crowd as if they were the dust beneath her feet; to behold the smatterer in learning, puffed up with a vain conceit of his superficial acquirements, when he has scarcely entered the porch of knowledge; in fine, to behold all ranks, from the highest to the lowest, big with an idea of their own importance, and fired with pride and revenge at the least provocation, whether imaginary or real! How inconsistent the manifestations of such tempers with the many humiliating circumstances of our present condition, and with the low rank which we hold in the scale of universal being!

It is not improbable that in the universe there are intelligencies of a superior order in whose breasts pride never found a place—to whom this globe of ours, and all its inhabitants, appear as inconsiderable as a drop of water filled with microscopic animalcules does to the proud lords of this earthly region. There is at least *one* Being to whom this sentiment is applicable in its utmost extents:—"Before HIM all nations are as a drop of a bucket, and the inhabitants of the earth as grasshoppers; yea, they are as nothing, and are counted to him less than nothing and vanity." Could we wing our way with the swiftness of a seraph, from sun to sun and from world to world, till we had surveyed all the systems visible to the naked eye, which are only as a mere speck in the map of the universe; could we, at the same time, contemplate the glorious landscapes and scenes of grandeur they exhibit; could we also mingle with the pure and exalted intelligencies which people those resplendent abodes, and behold their humble and ardent adorations of their Almighty Maker, their benign and condescending deportment towards one another; each esteeming another better than himself," and all united in the bonds of the purest affection, without one haughty or discordant feeling—what indignation and astonishment would seize us on our return to this obscure corner of creation, to behold beings enveloped in the mists of ignorance, immersed in depravity and wickedness, liable to a thousand accidents, exposed to the ravages of the earthquake, the volcano, and the storm; yet proud as Lucifer, and glorying in their shame!

We should be apt to view them, as we now do those bedlamites who fancy themselves to be kings surrounded by their nobles, while they are chained to the walls of a noisome dungeon. "Sure pride was never made for man." How abhorrent then must it appear in the eyes of superior beings, who have taken an expansive range through the fields of creation! How abhorrent it is in the sight of the Almighty, and how amiable is the opposite virtue, we learn from his word:—"Every one that is proud in heart is an abomination to the Lord." "God resisteth the proud, but he giveth grace to the humble." "Thus saith the high and lofty One who inhabiteth eternity, I dwell in the high and holy place; with him also that is of an humble and contrite spirit, to revive the spirit of the humble and the heart of the contrite ones." While therefore we contemplate the omnipotence of God in the immensity of creation, let us learn to cultivate humility and self-abasement. This was one of the lessons which the pious Psalmist deduced from his survey of the nocturnal heavens. When he beheld the moon walking in brightness, and the innumerable host of stars, overpowered with a sense of his own insignificance and the greatness of Divine condescension, he exclaimed, "O Lord! what is man that thou art mindful of him, or the son of man that thou shouldst visit him!"

Again, this subject is also calculated to inspire us with REVERENCE and VENERATION of God. Profound veneration of the Divine Being lies at the foundation of all religious worship and obedience. But in order to reverence God aright we must know him; and in order to acquire the true knowledge of him we must contemplate him through the medium of those works and dispensations by which he displays the glories of his nature to the inhabitants of our world. I have already exhibited a few specimens of the stupendous operations of his power, in that portion of the system of the universe which lies open to our inspection; and there is surely no mind in which the least spark of piety exists but must feel strong emotions of reverence and awe at the thought of that almighty and incomprehensible Being who impels the huge masses of the planetary globes with so amazing a rapidity through the sky, and who has diversified the voids of space with so vast an assemblage of magnificent worlds. Even those manifestations of Deity which are confined to the globe we inhabit, when attentively

considered, are calculated to rouse even the unthinking mind to astonishment and awe. The lofty mountains and expansive plains, the mass of waters in the mighty ocean, the thunders rolling along the sky, the lightnings flashing from cloud to cloud, the hurricane and the tempest, the volcano vomiting rivers of fire, and the earthquake shaking kingdoms and levelling cities with the ground—all proclaim the majesty of Him by whom the elements of nature are arranged and directed, and seem to address the sons of men in language like this:—"The Lord reigneth, he is clothed with majesty; at his wrath the earth trembles; a fire goeth before him and burneth up his enemies." "Let all the earth fear the Lord, let all the inhabitants of the world stand in awe of him."

There is one reason, among others, why the bulk of mankind feel so little veneration of God, and that is, that they seldom contemplate, with fixed attention, "the operations of his hands." If we wish to cherish this sublime sentiment in our hearts, we must familiarize our minds to frequent excursions over all those scenes of creation and providence, which the volume of nature and the volume of inspiration unfold to view. We must endeavour to assist our conceptions of the grandeur of these objects, by every discovery which has been or may yet be made, and by every mode of illustration by which a sublime and comprehensive idea of the particular object of contemplation may be obtained.—If we would wish to acquire some definite though imperfect conception of the physical extent of the universe, our minds might be assisted by such illustrations as the following:—Light flies from the sun with a velocity of nearly 200,000 miles in a moment of time, or about 1,400,000 times swifter than the motion of a cannon ball. Suppose that one of the highest order of intelligencies is endowed with a power of rapid motion superior to that of light, and a corresponding degree of intellectual energy; that he has been flying, without intermission, from one province of creation to another, for 6000 years, and will continue the same rapid course for 1,000,000,000 of years to come; it is highly probable, if not absolutely certain, that at the end of this vast tour he would have advanced no farther than "the suburbs of creation;" and that all the magnificent systems of material and intellectual beings he had surveyed during his rapid flight, and for such a length of ages, bear no more proportion to the whole empire of Omnipotence than the smallest grain

of sand does to all the particles of matter of the same size contained in 10,000 worlds. Nor need we entertain the least fear, that the idea of the extent of the Creator's power, conveyed by such a representation, exceeds the bounds of reality. On the other hand, it must fall almost infinitely short of it. For, as the poet has justly observed—

"Can man *conceive* beyond what God can *do?*"

Were a seraph, in prosecuting the tour of creation in the manner now stated, ever to arrive at a limit beyond which no further displays of the Divinity could be perceived, the thought would overwhelm his faculties with unutterable anguish and horror; he would feel that he had now, in some measure, comprehended all the plans and operations of Omnipotence, and that no further manifestations of the Divine glory remained to be explored. But we may rest assured that this can never happen in the case of any created intelligence. We have every reason to believe, both from the nature of an Infinite Being and from the vast extent of creation, already explored, that the immense mass of material existence, and the endless variety of sensitive and intellectual beings with which the universe is replenished, are intended by Jehovah to present to his rational offspring a *shadow*, an *emblem*, or a *representation*, (in so far as finite extended existence can be a representation) of the *infinite perfections* of his nature, which would otherwise have remained for ever impalpable to all subordinate intelligencies.

In this manner then might we occasionally exercise our minds on the grand and diversified objects which the universe exhibits; and, in proportion as we enlarge the sphere of our contemplations, in a similar proportion will our views of God himself be extended, and a corresponding sentiment of veneration impressed upon the mind. For the soul of man cannot reverence a mere abstract being, that was never manifested through a sensible medium, however many lofty terms may be used to describe his perfections. It reverences that ineffable Being who conceals himself behind the scenes of creation, through the medium of the visible display he exhibits of his power, wisdom, and beneficence in the economy of Nature, and in the records of Revelation.—Before the universe was formed, Jehovah existed alone, possessed of every attribute

which he now displays. But had only one solitary intelligence been created, and placed in the infinite void, without a material substratum beneath and around him, he could never have been animated with a sentiment of profound veneration for his Creator; because no objects existed to excite it, or to show that his invisible Maker was invested with those attributes which he is now known to possess. Accordingly, we find in the sacred writings that, when a sentiment of reverence is demanded from the sons of men, those sensible objects which are calculated to excite the emotion are uniformly exhibited. "Fear ye not me, saith the Lord? Will ye not tremble at my presence, who have placed the sand for the bound of the sea, by a perpetual decree, that it cannot pass it; and though the waves thereof toss themselves, yet they cannot prevail; though they roar, yet they cannot pass over it? Who would not fear thee, O King of nations! Thou art the true God, and an everlasting King. Thou hast made the earth by thy power, thou hast established the world by thy wisdom, thou hast stretched out the heavens by thy discretion. When thou utterest thy voice there is a noise of water in the heavens, thou causest the vapours to ascend, from the ends of the earth, thou makest lightnings with rain, and bringest forth the winds out of thy treasuries."[1]

But however enlarged and venerable conceptions of God we may derive from the manifestations of his power, they must fall infinitely short of what is due to a Being of boundless perfection. For there may be attributes in the Divine essence of which we cannot possibly form the least conception—attributes which cannot be shadowed forth or represented by any portion of the material or intellectual world yet discovered by us, or by all the mighty achievements by which human redemption was affected—attributes which have not yet been displayed, in their effects, to the highest orders of intelligent existence. And therefore, as that excellent philosopher and divine, the honourable Mr. Boyle, has well observed, "Our ideas of God, however great, will rather express the greatness of our veneration than the immensity of his perfections; and the notions worthy of the most intelligent men are far short of being worthy the incomprehensible God—the brighest idea we can frame of God being infinitely inferior, and no more

[1] Jeremiah, x, 7–13.

than a *parhelion*[1] in respect of the sun; for though that meteor is splendid, and resembles the sun, yet it resides in a cloud, and is not only much beneath the sun in distance, but inferior in bigness and splendour."

In short, were we habitually to cherish that profound veneration of God which his works are calculated to inspire, with what humility would we approach the presence of this august Being! with what emotions of awe would we present our adorations, and with what reverence would we talk of his inscrutable purposes and incomprehensible operations! We would not talk about him as some writers have done, with the same ease and indifference as a mathematician would talk about the properties of a triangle, or a philosopher about the effects of a mechanical engine; nor would we treat with a spirit of levity any of the solemn declarations of his word, or the mighty movements of his providence. We would be ever ready to join with ardour in the sublime devotions of the inspired writers, "Great and marvellous are thy works, Lord God Almighty, just and true are thy ways, thou King of saints! Who would not fear thee, O Lord, and glorify thy name? Let all the earth fear the Lord, let all the inhabitants of the world stand in awe of him."

Again, the views we have taken of the immensity of the universe, and of the innumerable beings it must contain, is calculated to raise our admiration of the *condescension* of God to man, especially in regard to the Redemption of our fallen world.—When we consider the vast range of the planetary system, and the magnitude of the bodies it contains—when we consider that the Sun and all his attendant planets, though many thousands of times larger than our globe, form only *one* out of many millions of systems dispersed throughout the infinitude of space, and extending far beyond what human eyes can penetrate, or human faculties can conceive—we have reason to exclaim with Solomon, in the language of wonder and astonishment, "Will God in very deed dwell with man on earth; Behold the heavens, and the *heaven of heavens* cannot

[1] A *Parhelion*, or *Mocksun*, is a meteor in the form of a very bright light appearing on one side of the sun, and somewhat resembling the appearance of that luminary. This phenomenon is supposed to be produced by the refraction and reflection of the sun's rays from a watery cloud. Sometimes three or four of these parhelia, all of them bearing a certain resemblance to the real sun, have been seen at one time.

contain him!" "He sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers. All nations before Him are as nothing, and less than nothing and vanity." The expression "the heavens," evidently denotes the *visible* firmament with all the stars and planets perceptible to the unassisted eye; but the phrase "heaven of heavens," is an expression of a far more extensive and sublime import. It evidently intimates that far beyond the visible starry heavens which we behold, there are unnumbered firmaments, composed of other stars and systems, stretching out towards infinity on either hand, and which mortals in their present state will never be able to descry. We have, however, obtained some glimpses of such firmaments. More than a hundred millions of stars, in addition to those distinguishable by the naked eye, are within the reach of telescopes; and we behold hundreds and even thousands of Nebulæ in different spaces—each of them consisting of thousands of stars—which would form a firmament as glorious and extensive as that which appears in our midnight sky; and were we removed from one of those nebulæ to another we should behold at every stage a new firmament composed of luminaries altogether different from what we had beheld before. "Will God, then, indeed dwell with man upon earth?" since, far beyond the range of the material universe, he resides in the glory of his invisible attributes, filling immensity with his presence!

This sentiment likewise seems to have deeply impressed the mind of the Psalmist when contemplating the glories of a starry sky. Beholding the resplendent orbs every where around him in the canopy of heaven—the moon shedding her mild radiance, the planets moving along in their several courses, and the innumerable host of stars dispersed over the concave of the sky—his thoughts seem to have taken a flight into the regions of immensity, and under the guidance of his rational powers, and the assistance of the Divine Spirit—he takes an expansive view of the magnitude, the multitude, and magnificence of those globes which roll in the distant spaces of creation. Overwhelmed with his views of the vastness of the universe, and of the perfections and grandeur of Him who formed and who rules over it, he breaks out in the language of admiration and astonishment—"Lord, what is *man* that thou art mindful of him, or the son of man that thou visitest him." Surveying with his

intellectual eye the boundless extent of God's universal empire, he shrinks as it were into nothing, and seems almost afraid lest he should be overlooked or forgotten amidst the immensity of beings over which the Divine government extends. And when he considered himself as a guilty creature, and a rebel against the government of the Most High, his astonishment at the condescension and grace of Jehovah must have been greatly increased.

In no dispensation of the Almighty towards our world is this divine condescension so strikingly displayed as in the economy of our redemption. We have reason to believe that the universe throughout its vast extent, is replenished with intelligencies of various ranks and orders, with powers superior to those of man. The greater part, if not the whole of those exalted beings, we have reason to believe, have retained their primeval innocence, and are continually employed in celebrating the high praises of their Creator, and "hearkening to the voice of his word." "The host of heaven," says the inspired prophet, "*worshippeth thee;*" which implies, that the numerous worlds which exist throughout creation are peopled with inhabitants—that these inhabitants are endowed with powers of intellect—that their numbers correspond with the amplitude of the regions they occupy—that they are invested with moral perfection, and that they employ their faculties in contemplating the perfections and operations of their Creator, and pay him a tribute of adoration and praise. For "worshipping God" necessarily implies in it, that the beings who are qualified to engage in this service are furnished with moral and intellectual powers capable of appreciating his perfections and of perceiving that he is worthy of all homage and adoration. Therefore it appears that although all the apostate inhabitants of our world had been swept away as nuisances from the face of creation, they would never have been missed, amidst the immensity of worlds and beings which compose the universe, more than a grain of sand from the sea-shore. Yet —amazing to relate, the joyful announcement was proclaimed from heaven to our rebellious race," God so loved the world that he gave his only-begotten Son, that whosoever believeth on him should not perish but have everlasting life." A messenger from the celestial regions was despatched to the plains of Bethlehem to proclaim "Good tidings of great joy to all people"—" Glory to God in the highest, peace on earth, and good will towards men." And when

the great Deliverer offered up himself a sacrifice for sin, a series of august and striking miracles was exhibited in order to display the dignity of Him who suffered, and to convince surrounding spectators of the importance of that event. The sun was clad in black, the day was transformed into night—for three hours darkness covered the whole land—the earth did quake—the rocks rent asunder—the vail of the temple was rent in twain from the top to the bottom—the graves were opened, and the inhabitants of the tomb arose to life.

This was the most wonderful event and the most illustrious display of divine love and grace that was ever manifested to our world.

What displays of divine love and mercy may have been made to other worlds, or other orders of beings, we are not in a situation to determine. We dare not affirm that, in other regions of the divine empire similar displays—if they were required—have not been made; for we have never traversed the depths of immensity and penetrated within the confines of other orders of intelligencies to ascertain all the dispensations of the Almighty in every province of his universal kingdom. For anything we know to the contrary, there *may be* worlds and beings who have swerved from their original integrity, and towards whom a similar or analogous manifestation of divine mercy may have been made. But, whatever may be the case in this respect, we may boldly affirm that the mission and the death of Christ Jesus were the most wonderful events and the most astonishing displays of love and mercy that were ever made to *our* sublunary world. As an inspired apostle has declared, there is "a height and a depth, a breadth and a length in the love of God which is in Christ Jesus that passeth all understanding." When we consider the depths of misery from which it raises us, the heights of happiness to which it exalts us, the boundless nature of its operations, the low rank which man holds in the scale of universal being, and the everlasting duration of all the blessings of Redeeming love—we have reason to exclaim with the enraptured poet.

> "O goodness infinite! goodness immense!
> And love that passeth knowledge, words are vain,
> Language is lost in wonders so sublime,
> Come, then, expressive silence, muse his praise."

Lastly, The views we have taken of the omnipotence and gran-

deur of the Deity are calculated to inspire us with HOPE and CONFIDENCE in the prospect of that eternal existence which lies before us. The period of our existence in this terrestrial scene will soon terminate, and those bodies, through which we now hold a correspondence with the visible creation, crumble into dust. The gradual decay and the ultimate dissolution of human bodies present a scene at which reason stands aghast; and on a cursory survey of the chambers of the dead, it is apt to exclaim in the language of despair, "Can these dry bones live?" A thousand difficulties crowd upon the mind which appear repugnant to the idea, that "beauty shall again spring out of ashes, and life out of the dust." But, when we look abroad to the displays of Divine power and intelligence in the wide expanse of creation, we perceive that

> "Almighty God
> Has done much more; nor is his arm impair'd
> Through length of days.—And what he can he will;
> His faithfulness stands bound to see it done."—BLAIR.

We perceive that he has created systems in such vast profusion that no man can number them. The worlds every moment under his superintendence and direction are unquestionably far more numerous than all the human beings who have hitherto existed or will yet exist to the close of time. And if he has not only arranged the general features of each of these worlds, and established the physical laws by which its economy is regulated, but has also arranged the diversified circumstances, and directs the minutest movements of the myriads of sensitive and intellectual existences it contains, we ought never for a moment to doubt that the minutest particles of every human body, however widely separated from each other, and mingled with other extraneous substances, are known to him whose presence pervades all space; and that all the atoms requisite for the construction of the resurrection-body will be re-assembled for this purpose "by the energy of that mighty power whereby he is able to subdue all things to himself." If we suppose that a number of human beings, amounting to 300,000,000,000, shall start from the grave into new life at the general resurrection, and that the atoms of each of these bodies are just now under the special superintendence of the Almighty; and that at least an equal number of worlds are under his particular care and direc-

tion; the exertions of power and intelligence, in the former case, cannot be supposed to be greater than what is requisite in the latter. To a being possessed of infinite power, conjoined with boundless intelligence, the superintendence of countless atoms and of countless worlds is equally easy where no contradiction is implied. For as the poet has well observed,—

> "He summons into being with like ease
> A whole creation and a single grain."

And since this subject tends to strengthen our hope of a resurrection from the dead, it is also calculated to inspire us with confidence in the prospect of those eternal scenes which will burst upon the view at the dissolution of all terrestrial things. Beyond the period fixed for the conflagration of this world, "a wide and unbounded prospect lies before us:" and though "shadows, clouds, and darkness rest upon it" at present, yet the boundless magnificence of the Divine empire which science has unfolded throws a radiance over the scenes of futurity, which is fraught with consolation in the view of "the wreck of matter and the crush of worlds." It opens to us a prospect of perpetual improvement in knowledge and felicity; it presents a field in which the human faculties may be for ever expanding, for ever contemplating new scenes of grandeur rising to the view, in boundless perspective, through an interminable succession of existence. It convinces us, that the happiness of the eternal state will not consist in an unvaried repetition of the same perceptions and enjoyments, but that new displays of the Creator's glory will be continually bursting on the astonished mind, world without end. And as we know that the same beneficence and care which are displayed in the arrangements of systems of worlds, are also displayed in supporting and providing for the smallest microscopic animalcules, we have no reason to harbour the least fear lest we should be overlooked in the immensity of creation, or lost amidst the multiplicity of those works among which the Deity is incessantly employed: for as he is *omnipresent*, his essence pervades, actuates, and supports the whole frame of universal nature, and all the beings it contains; so that he is as intimately present with every created being, whether sensitive or intellectual, as that being is to itself. And, as he is *omniscient* he is conscious of every movement that

can arise in the material system, and of every thought and purpose that can pervade the world of intellectual existence,—and consequently his superintendence and care must extend to every creature he has formed. Therefore, though the "elements shall melt with fervent heat, and the earth and all the works that are therein be dissolved, yet we, according to his promise, look for new heavens and a new earth, wherein dwelleth righteousness."

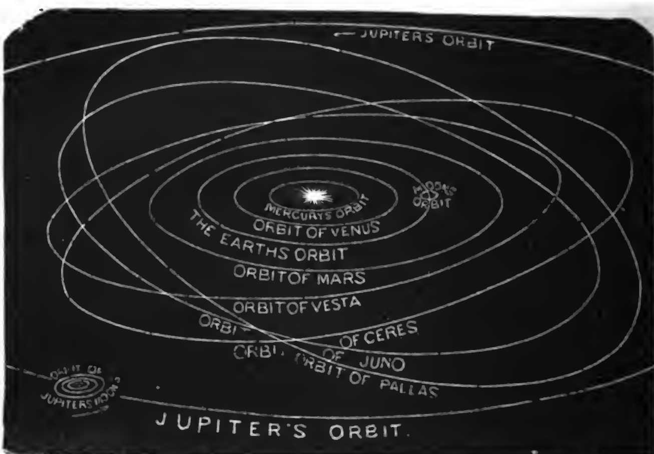
SECTION III.

ON THE WISDOM AND INTELLIGENCE OF THE DEITY.

In surveying the system of nature with a Christian and a philosophic eye, it may be considered in different points of view. It may be viewed either as displaying the power and magnificence of the Deity in the immense quantity of materials of which it is composed, and in the august machinery and movements by which its economy is directed; or as manifesting his wisdom in the nice adaptation of every minute circumstance to the end it was intended to accomplish; or as illustrating his unbounded beneficence in the provision which is made for the accommodation and happiness of the numerous tribes of sentient and intelligent beings it contains. Having, in the preceding section, endeavoured to exhibit some of those objects which evince the omnipotence of Deity, and the pious emotions they are calculated to excite, I shall now offer a few popular illustrations of divine wisdom as displayed in the arrangements of the material world, which shall chiefly be confined to those objects which are most prominent and obvious to the vulgar eye.

Wisdom is that perfection of an intelligent agent by which he is enabled to select and employ the most proper means in order to accomplish a good and important end. It includes the idea of knowledge or intelligence, but may be distinguished from it. Knowledge is opposed to ignorance, wisdom is opposed to folly or error in conduct. As applied to God, it may be considered as comprehending the operations of his omniscience and benevolence; or, in other words, his knowledge to discern, and his disposition to choose those means and ends which are calculated to promote the order and the happiness of the universe.

The wisdom of God is doubtless displayed in every arrangement he has made throughout all the provinces of his immense and eternal kingdom, however far they may be removed from the sphere of human observation. But it is only in those parts of the system of nature which lie open to our particular investigation, that the traces of this perfection can be distinctly perceived. The *heavens* declare the glory of God's wisdom, as well as of his power.



ORBITS OF PLANETS. SOLAR SYSTEM.

The planetary system—that portion of the heavens with which we are best acquained—displays both the magnificence and the skill of its divine Author, in the magnitudes, distances, revolutions, proportions, and uses of the various globes of which it is composed, and in the diversified apparatus by which light and darkness are alternately distributed. The sun, an immense luminous world, by far the largest body in the system, is placed in the centre. No other position would have suited for an equable distribution of illumination and heat through the different parts of the system. Around him, at different distances, 40 primary planets revolve, accompanied with 20 secondaries or moons,—all in majestic order

and harmony, no one interrupting the movements of another, but invariably keeping the path prescribed them, and performing their revolutions in their appointed times. To all these revolving globes the sun dispenses motion, light, heat, fertility, and other unceasing energies, for the comfort and happiness of their respective inhabitants — without which perpetual sterility, eternal winter and eternal night, would reign over every region of our globe and throughout surrounding worlds.

The distance at which the heavenly bodies, particularly the sun, are placed from the earth, is a manifest evidence of divine wisdom. If the sun were much nearer us than he is at present, the earth, as now constituted, would be wasted and parched with excessive heat; the waters would be turned into vapour, and the rivers, seas, and oceans, would soon disappear, leaving nothing behind them but frightful barren dells and gloomy caverns; vegetation would completely cease, and the tribes of animated nature languish and die. On the other hand, were the sun much farther distant than he now is, or were his bulk, or the influence of his rays diminished one half of what they now are, the land and the ocean would soon become one frozen mass, and universal desolation and sterility would overspread the fair face of nature; and instead of a pleasant and comfortable abode, our globe would become a frightful desert, a state of misery and perpetual punishment.[1] But herein is the wisdom of God displayed, that he has formed the sun of such a determinate size, and placed it at such a convenient distance, as not to annoy, but to refresh and cheer us, and to enliven the soil with its genial influence; so that we plainly perceive, to use the language of the prophet, that "He hath established the world by his wisdom, and stretched out the heavens by his understanding."

[1] It forms no objection to these remarks that *ca'oric*, or the matter of *heat*, does not altogether depend upon the direct influence of the solar rays. The substance of caloric may be chiefly connected with the constitution of the globe we inhabit. But still it is quite certain that the earth, *as presently constituted*, would suffer effects most disastrous to sentient beings were it removed much nearer to or much farther from the central luminary. Those planets which are removed several hundreds of millions of miles farther from the sun than our globe may possibly experience a degree of heat much greater than ours; but in this case the constitution of the solid parts of these globes, and of their surrounding atmospheres, must be very different from what obtains in the physical arrangements of our globe.

The rotation of the several planetary globes around their axis to produce the alternate succession of day and night, strikingly demonstrates the wisdom and benevolence of their great Author. Were the earth and the other planetary worlds destitute of a diurnal motion, only one half of their surfaces could be inhabited, and the other half would remain a dark and cheerless desert. The sun would be the only heavenly orb which would be recognized by the inhabitants of each respective world as existing in the universe, and that scene of grandeur which night unfolds in the boundless expanse of the sky would be for ever vailed from their view. For it appears to be one grand design of the Creator, in giving these bodies a diurnal motion, not only to cheer their inhabitants with light and warmth, and the gay colouring produced by the solar rays, but also to open to them a prospect of other portions of his vast dominions which are dispersed in endless variety throughout the illimitable regions of space, in order that they may acquire a more sublime impression of the glory of his kingdom, and of his eternal power and Godhead. But were perpetual day to irradiate the planets, it would throw an eternal and impenetrable vail over the glories of the sky, behind which the magnificent operations of Jehovah's power would be in a great measure concealed. It is this circumstance which we should consider as the principal reason why a rotatory motion has been impressed on the planetary globes; and not merely that a curtain of darkness might be thrown around their inhabitants during the repose of sleep, as in the world in which we dwell. For in some of the other planetary worlds belonging to our system the intelligent beings with which they are peopled may stand in no need of that nocturnal repose which is necessary for man; their physical powers may be incapable of being impaired, and their mental energies may be in perpetual exercise. And in some of those bodies which are surrounded with an assemblage of rings and moons, as the planet Saturn, the diversified grandeur of their celestial phenomena, in the absence of the sun, may present a scene of contemplation and enjoyment far more interesting than all the splendours of their noonday. Besides, had the planets no motion round their axes, and were both their hemispheres supposed to be peopled with inhabitants, their physical state and enjoyments would be as opposite to each other as if they lived under the government of two distinct independent

beings. While the one class was basking under the splendours of perpetual day, the other would be involved in all the horrors of an everlasting night. While the one hemisphere would be parched with excessive heat, the other would be bound in the fetters of eternal ice; and in such a globe as ours, the motion of the tides, the ascent of the vapours, the currents of the atmosphere, the course of the winds, the benign influences of the rains and dews, and a thousand other movements, which produce so many salutary and beneficial effects, would be completely deranged. Hence we find, that on all the planetary bodies on which spots have been discovered, a rotatory motion actually exists,[1] in the secondary as well as in the primary planets, and even in the sun itself, the centre and the mover of the whole: in which arrangement of the almighty Creator the evidences of wisdom and design are strikingly apparent.

This amazing scene of divine workmanship and skill which the planetary system exhibits, we have reason to believe, is multiplied and diversified to an indefinite extent, throughout all the other systems of creation, displaying to the intelligencies of every region "the manifold wisdom of God." For there can be no question, that every star we now behold, either by the naked eye or by the help of a telescope, is the centre of a system of planetary worlds, where the agency of God and his unsearchable wisdom may be endlessly varied, and perhaps more strikingly displayed than even in the system to which we belong. These vast globes of light could never have been designed merely to shed a few glimmering rays on our far distant world: for the 10,000th part of them has never yet been seen by the inhabitants of the earth since the Mosaic creation, except by a few astronomers of the past and present age; and the light of many of them, in all probability, has never yet reached us, and perhaps never will till the period of the consummation of all terrestrial things. They were not made in vain: for such a supposition would be inconsistent with every idea we can form of the

[1] On the planet *Uranus*, or Herschel, no spots or inequalities of surface have been discovered, on account of its great distance from the earth; but spots have been discovered on the planets Saturn, Jupiter, Mars, and Venus, by which their diurnal rotations have been ascertained. There can be no doubt, however, that Uranus rotates on an axis as well as the other planets, although its distance prevents us from determining this point by actual observation.

attributes of a Being of infinite perfection. They were not intended merely to diversify the voids of infinite space with a useless splendour which has no relation to intellectual natures; for this would give us a most distorted and inconsistent idea of the character of Him "who is the only wise God;" and we are told by an authority which cannot be questioned, that "by his wisdom he made the heavens, and stretched them out by his understanding." The only rational conclusion therefore which can be deduced is, that they are destined to distribute illumination and splendour, vivifying influence and happiness, among incalculable numbers of intelligent beings, of various degrees of physical, moral, and intellectual excellence. And wherever the Creator has exerted his almighty energies in the production of sensitive and intellectual natures, we may rest assured that there also his infinite wisdom and intelligence, in an endless variety of arrangements, contrivances, and adaptations, are unceasingly displayed.

But, after all, whatever evidences of contrivance and design the celestial globes may exhibit, it is not in the heavens that the most striking displays of divine *wisdom* can be traced by the inhabitants of our world. It is only a few *general relations* and adaptations that can be distinctly perceived among the orbs of the firmament; though, in so far as we are able to trace the purposes which they subserve, the marks of beauty, order, and design, are uniformly apparent. But we are placed at too great a distance from the orbs of heaven, to be able to investigate the particular arrangements which enter into the physical and moral economy of the celestial worlds. Were we transported to the surface of the planet Jupiter, and had an opportunity of surveying, at leisure, the regions of that vast globe, and the tribes of sensitive and intellectual existence which compose its population—of contemplating the relations of its moons to the pleasure and comfort of its inhabitants—the constitution of its atmosphere as to its reflective and refractive powers, in producing a degree of illumination to compensate for the great distance of that planet from the sun—its adaptation to the functions of animal life—the construction of the visual organs of its inhabitants, and the degree of sensibility they possess, corresponding to the quantity of light received from the sun—the temperature of the surface and atmosphere of this globe, corresponding to its distance from the central source of heat, and to the physical

constitution of sensitive beings—in short, could we investigate the relations which inanimate nature, in all its varieties and sublimities, bears to the necessities and the happiness of the animated existences which traverse its different regions, we should doubtless behold a scene of divine wisdom and intelligence far more admirable and astonishing than even that which is exhibited in our sublunary world.—But since it is impossible for us to investigate the economy of other worlds, while we are chained down to this terrestrial sphere, we must direct our attention to those arrangements and contrivances in the constitution of our own globe which lie open to our particular inspection, in order to perceive more distinctly the benevolent designs of Him "in whom we live and move and have our being." And here an attentive observer will find in almost every object, when minutely examined, a display of goodness and intelligence which will constrain him to exclaim, "O the depth of the riches both of the wisdom and the knowledge of God!"

Wisdom, considered as consisting in contrivance, or the selection of the most proper means in order to accomplish an important end, may be exemplified and illustrated in a variety of familiar objects in the scene of nature.

The *earth* on which we tread was evidently intended by the Creator to support man and other animals, along with their habitations, and to furnish those vegetable productions which are necessary for their subsistence; and accordingly he has given it that exact degree of consistency which is requisite for these purposes. Were it much harder than it now is—were it, for example, as dense as a rock, it would be incapable of cultivation, and vegetables could not be produced from its surface. Were it softer, it would be insufficient to support us, and we should sink at every step, like a person walking in a quagmire. No buildings, such as those we now construct, could have been supported, and no conveyances, such as coaches and steam carriages, could have moved along its surface. Had this circumstance not been attended to in its formation, the earth would have been rendered useless as a habitable world for all those animated beings which now traverse its different regions. The exact adjustment of the solid parts of our globe to the nature and necessities of the beings which inhabit is therefore an instance and an evidence of *wisdom.*

The *diversity of surface* which it every where presents, in the

mountains and vales with which it is variegated, indicates the same benevolent contrivance and design. If the earth were divested of its mountains, and its surface every where uniformly smooth, there would be no rivers, springs, or fountains; for water can flow only from a higher to a lower place; the vegetable tribes would droop and languish; man and other animals would be deprived of what is necessary for their existence and comfort; we should be destitute of many useful stones, minerals, plants, and trees, which are now produced on the surface and in the interior of mountains; the sea itself would become a stagnant marsh, or overflow the land; and the whole surface of nature in our terrestrial sphere would present an unvaried scene of dull uniformity. Those picturesque and sublime scenes which fire the imagination of the poet, and which render mountainous districts so pleasing to the philosophic traveller, would be completely withdrawn; and all around, when compared with such diversified landscapes, would appear as fatiguing to the eye as the vast solitudes of the Arabian deserts, or the dull monotony of the ocean. But, in consequence of the admirable distribution of hills and mountains over the surface of our globe, a variety of useful and ornamental effects is produced. Their lofty summits are destined by providence to arrest the vapours which float in the regions of the air; their internal cavities form so many spacious basins for the reception of water distilled from the clouds; they are the original sources of springs and rivers, which water and fertilize the earth; they form immense magazines, in which are deposited stones, metals, and minerals, which are of so essential service in the arts that promote the comfort of human life; they serve for the production of a vast variety of herbs and trees; they arrest the progress of storms and tempests; they afford shelter and entertainment to various animals which minister to the wants of mankind: in a word, they adorn and embellish the face of nature; they form thousands of sublime and beautiful landscapes, and afford from their summits the most delightful prospects of the plains below. All these circumstances demonstrate the consummate wisdom of the great Architect of nature, and lead us to conclude that mountains, so far from being rude excrescences of nature, as some have asserted, form an essential part in the constitution, not only of our globe, but of all habitable worlds. And this conclusion is confirmed, so far as our observation extends, with regard to the moon and several

of the planetary bodies which belong to our system, whose surfaces are found to be diversified by sublime ramifications of mountain scenery; which circumstance forms one collateral proof, among many others, that they are the abodes of sentient and intellectual beings.

Again, the *colouring* which is spread over the face of nature indicates the wisdom of the Deity. It is essential to the present mode of our existence, and it was evidently intended by the Creator that we should be enabled easily to recognize the forms and properties of the various objects with which we are surrounded. But were the objects of nature destitute of colour, or were the same unvaried hue spread over the face of creation, we should be destitute of all the entertainments of vision, and be at a loss to distinguish one object from another. We should be unable to distinguish rugged precipices from fruitful hills, naked rocks from human habitations, the trees from the hills that bear them, and the tilled from the untilled lands. "We should hesitate to pronounce whether an adjacent enclosure contains a piece of pasturage, a plot of arable land, or a field of corn; and it would require a little journey, and a minute investigation, to determine such a point. We could not determine whether the first person we met were a soldier in his regimentals, or a swain in his Sunday suit; a bride in her ornaments, or a widow in her weeds." Such would have been the aspect of nature, and such the inconveniences to which we should have been subjected, had God allowed us light without the distinction of colours. We could have distinguished objects only by intricate trains of reasoning, and by circumstances of time, place, and relative position. And to what delays and perplexities should we have been reduced had we been obliged every moment to distinguish one thing from another by reasoning? Our whole life must then have been employed rather in study than in action; and after all we must have remained in eternal uncertainty as to many things which are now quite obvious to every one as soon as he opens his eyes. We could neither have communicated our thoughts by writing, nor have derived instruction from others through the medium of books; for it is the contrast of different colours which enables us to distinguish the letters, words, and sentences, in a written or printed book; so that we should now have been almost as ignorant of the transactions of past ages as we are of the events which

are passing in the planetary worlds; and, consequently, we could never have enjoyed a written revelation from heaven, nor any other infallible guide to direct us in the path to happiness, if the Almighty had not distinguished the rays of light, and painted the objects around us with a diversity of colours—so essentially connected are the minutest and the most magnificent works of Deity. But now, in the present constitution of things, colour characterizes the class to which every individual belongs, and indicates, upon the first inspection, its respective quality. Every object wears its peculiar livery, and has a distinguishing mark by which it is characterized.

The different hues which are spread over the scenery of the world are also highly ornamental to the face of nature, and afford a variety of pleasures to the eye and the imagination. It is this circumstance which adds a charm to the fields, the valleys, and the hills, the lofty mountain, the winding river, and the expansive lake; and which gives a splendour and sublimity to the capacious vault of heaven. Colour is therefore an essential requisite to every world inhabited by sensitive beings; and we know, that provision has been made for diffusing it throughout all the globes which may exist in the distant regions which our telescopes have penetrated; for the light which radiates from the most distant stars is capable of being separated into the prismatic colours, similar to those which are produced by the solar rays; which furnishes a presumptive proof, that they are intended to accomplish designs, in their respective spheres, analogous to those which light subserves in our terrestrial habitation; or, in other words, that they are destined to convey to the minds of sentient beings impressions of light and colour, and consequently, beings susceptible of such impressions must reside within the sphere or more immediate influence of these far distant orbs.

The same benevolent design is apparent in the *general colour which prevails throughout the scene of sublunary nature.* Had the fields been clothed with hues of a deep red, or a brilliant white, the eye would have been dazzled with the splendour of their aspect. Had a dark blue or a black colour generally prevailed, it would have cast a universal gloom over the face of nature. But an agreeable *green* holds the medium between these two extremes, equally remote from a dismal gloom and excessive splendour, and bears such a relation to the structure of the eye, that it refreshes

instead of tiring it, and supports instead of diminishing its force. At the same time, though one general colour prevails over the landscape of the earth, it is diversified by an admirable variety of shades, so that every individual object in the vegetable world can be accurately distinguished from another; thus producing a beautiful and variegated appearance over the whole scenery of nature. "Who sees not, in all these things, that the hand of the Lord hath wrought this?"

If from the earth we turn our attention to the *waters*, we shall perceive similar traces of the exquisite wisdom and skill of the Author of nature. Water is one of the most essentially elementary parts in the constitution of our globe, without which the various tribes of beings which now people it could not exist. It supplies a necessary beverage to man, and to all the animals that people the earth and the air. It forms a solvent for a great variety of solid bodies; it is the element in which an infinitude of organized beings pass their existence; it acts an important part in conveying life and nourishment to all the tribes of the vegetable kingdom, and gives salubrity to the atmospherical regions. Collected in immense masses in the basins of the sea, it serves as a vehicle for ships, and as a medium of communication between people of the most distant lands. Carried along with a progressive motion over the beds of streams and of rivers, it gives a brisk impulse to the air, and prevents the unwholesome stagnation of vapours; it receives the filth of populous cities, and rids them of a thousand nuisances. By its impulsion, it becomes the mover of a multitude of machines; and, when rarified into steam, it is transformed into one of the most powerful and useful agents under the dominion of man. All which beneficial effects entirely depend on the exact degree of density or specific gravity which the Creator has given to its constituent parts. Had it been much more rarified than it is, it would have been altogether unfit to answer the purposes now specified; the whole face of the earth would have been a dry and barren waste; vegetable nature could not have been nourished; our floating edifices could not have been supported; the lightest bodies would have sunk, and all regular intercourse with distant nations would have been prevented. On the other hand, had its parts been much denser than they are; for example, had they been of the consistency of a thin jelly, similar disastrous effects would

have inevitably followed, no ships could have ploughed the ocean —no refreshing beverage would have been supplied to the animal tribes—the absorbent vessels of trees, herbs, and flowers, would have been unable to imbibe the moisture requisite for their nourishment, and we should thus have been deprived of all the beneficial effects we now derive from the use of that liquid element, and of all the diversified scenery of the vegetable world. But the configuration and consistency of its parts are so nicely adjusted to the constitution of the other elements, and to the wants of the sensitive and vegetable tribes, as exactly to subserve the ends intended in the system of nature.

Water has been ascertained to be a compound body, formed by the union of two different kinds of air—oxygen and hydrogen. It has the property of becoming, in certain cases, much lighter than air; though, in its natural liquid state, it is 800 times heavier than that fluid; and has also the property of afterwards resuming its natural weight. Were it not for this property, evaporation could not be produced: and, consequently, no clouds, rain, nor dew could be formed, to water and fertilize the different regions of the earth. But in consequence of this wonderful property, the ocean becomes an inexhaustible cistern to our world. From its expansive surface are exhaled those vapours which supply the rivers and nourish the vegetable productions of every land. "The air and the sun," says an elegant writer, "constitute the mighty engine that works without intermission to raise the liquid treasures; while the clouds serve as so many aqueducts to convey them along the atmosphere, and distribute them at seasonable periods, and in regular proportions, through all the regions of the globe."

Notwithstanding the properties now stated, *motion was still requisite*, to insure all the advantages we now derive from the liquid element. Had the whole mass of waters been in a stagnant state, a thousand inconveniences and disastrous consequences would have inevitably ensued. But the all-wise Creator has impressed upon its various masses a circulating motion, which preserves its purity and widely extends its beneficial influence. The rills pour their liquid stores into the rivers; the rivers roll their watery treasures into the ocean; the waters of the ocean, by a libratory motion, roll backwards and forwards every twelve hours, and by means of currents and the force of winds are kept in constant agitation. By

the solar heat, a portion of these waters is carried up into the atmosphere, and, in the form of clouds, is conveyed by the winds over various regions; till at last it descends in rain and dew, to supply the springs "which run among the hills." So that there is a constant motion and circulation of the watery element, that it may serve as an agent for carrying forward the various processes of nature, and for ministering to the wants of man and beast.

In fine, were the waters in a state of perpetual stagnation, the filth of populous cities would be accumulated to a most unwholesome degree; the air would be filled with putrid exhalations, and the vegetable tribes would languish and die. Were they deprived of the property of being evaporated, (in which state they occupy a space 1600 times greater than in their liquid state,) rain and dew could never be produced, and the earth would be turned into "a dry and parched wilderness;" neither grass nor corn could be sufficiently dried to lay up for use; *our clothes, when washed, could never be dried;* and a variety of common operations which now conduce to our convenience and comfort could never be carried on. But the infinite wisdom of the Creator, foreseeing all the effects which can possibly arise from these principles of nature, has effectually provided against such disasters, by arranging all things in number, weight, and measure, to subserve the beneficial ends for which they were ordained. "He causeth the vapours to ascend from the ends of the earth;" "he sendeth the springs into the valleys, which run among the hills. They give drink to every beast of the field; the wild asses quench their thirst. By them the fowls of heaven have their habitation, which sing among the branches. He watereth the hills from his chambers: the earth is satisfied with the fruit of his works."

Let us now attend to the *atmosphere,* in the constitution of which the wisdom of God is no less conspicuous than in the other departments of nature.

The atmosphere is one of the most essential appendages to the globe we inhabit, and exhibits a most striking scene of Divine skill and omnipotence. The term *atmosphere* is applied to the whole mass of fluids, consisting of air, vapours, electric fluid, and other matters, which surround the earth to a certain height. This mass of fluid matter gravitates to the earth, revolves with it in its diurnal rotation, and is carried along with it in its course round the

sun every year. It has been computed to extend about 45 miles above the earth's surface, and it presses on the earth with a force proportioned to its height and density. From experiments made by the barometer, it has been ascertained that it presses with a weight of about 15 pounds on every square inch of the earth's surface; and therefore its pressure on the body of a middle-sized man is equal to about 32,000 pounds, or 14 tons avoirdupois, a pressure which would be insupportable, and even fatal, were it not equal in every part, and counterbalanced by the spring of the air within us. The pressure of the whole atmosphere upon the earth is computed to be equivalent to that of a globe of lead 60 miles in diameter, or about 5,000,000,000,000,000 tons; that is, the whole mass of air which surrounds the globe compresses the earth with a force or power equal to that of *five thousand millions of millions of tons.*[1] This amazing pressure is, however, essentially necessary for the preservation of the present constitution of our globe, and of the animated beings which dwell on its surface. It prevents the heat of the sun from converting water and all other fluids on the face of the earth into vapour; and preserves the vessels of all organized beings in due tone and vigour. Were the atmospherical pressure entirely removed, the elastic fluids contained in the finer vessels of men and other animals would inevitably burst them, and life would become extinct;[2] and most of the substances on the face of the earth, particularly liquids, would be dissipated into vapour.

[1] See Appendix, Note II.

[2] The necessity of the atmospherical pressure, for the comfort and preservation of animal life, might be illustrated by the effects experienced by those who have ascended to the summits of very high mountains, or who have been carried to a great height above the surface of the earth in balloons. Acosta, in his relation of a journey among the mountains of Peru, states that " he and his companions were surprised with such extreme pangs of straining and vomiting, not without casting up of blood too, and with so violent a distemper, that they would undoubtedly have died had they remained two or three hours longer in that elevated situation." Count Zambeccari and his companions, who ascended in a balloon on the 7th November, 1783, to a great height, found their hands and feet so swelled, that it was necessary for a surgeon to make incisions in the skin. In both the cases now stated, the persons ascended to so great a height that the pressure of the atmosphere was not sufficient to counterbalance the pressure of the fluids of the body.

The atmosphere is now ascertained to be a compound substance, formed of two very different ingredients, termed *oxygen gas,* and *nitrogen gas.* Of 100 measures of atmospheric air, 21 are oxygen, and 79 nitrogen. The one, namely oxygen, is the principle of combustion and the vehicle of heat, and is absolutely necessary for the support of animal life, and is the most powerful and energetic agent in nature; the other is altogether incapable of supporting either flame or animal life. Were we to breathe oxygen air, without any mixture or alloy, our animal spirits would be raised, and the fluids in our bodies would circulate with greater rapidity; but we would soon infallibly perish by the rapid and unnatural accumulation of heat in the animal frame. If the nitrogen were extracted from the air, and the whole atmosphere contained nothing but oxygen or vital air, combustion would not proceed in that gradual manner which it now does, but with the most dreadful and irresistible rapidity: not only wood and coals, and other substances now used for fuel, but even stones, iron and other metallic substances, would blaze with a rapidity which would carry destruction through the whole expanse of nature. If even the proportions of the two airs were materially altered, a variety of pernicious effects would instantly be produced. If the oxygen were less in quantity than it now is, fire would lose its strength, candles would not diffuse a sufficient light, and animals would perform their vital functions with the utmost difficulty and pain. On the other hand, were the nitrogen diminished and the oxygen increased, the air taken in by respiration would be more stimulant, and the circulation of the animal fluids would become accelerated; but the tone of the vessels thus stimulated to increased action would be destroyed by too great an excitement, and the body would inevitably waste and decay. Again, were the oxygen completely extracted from the atmosphere, and nothing but nitrogen to remain, fire and flame would be extinguished, and instant destruction would be carried throughout all the departments of vegetable and animated nature. For a lighted taper will not burn for a single moment in nitrogen gas, and if an animal be plunged into it, it is instantly suffocated.

Again, not only the extraction of any one of the component parts of the atmosphere, or the alteration of their respective proportions, but even the slightest increase or diminution of their *specific gravity,* would be attended with the most disastrous effects.

The nitrogen is found to be a little lighter than common air, which enables it to rise towards the higher regions of the atmosphere. In breathing, the air which is evolved from the lungs at every expiration consists chiefly of nitrogen, which is entirely unfit to be breathed again, and therefore rises above our heads before the next inspiration. Now, had nitrogen, instead of being a little lighter, been a slight degree heavier than common air, or of the same specific gravity, it would have accumulated on the surface of the earth, and particularly in our apartments, to such a degree as to have produced diseases, pestilence, and death, in rapid succession. But being a little lighter than the surrounding air, it flies upwards, and we never breathe it again till it enter into new and salutary combinations. Such is the benevolent skill which the Author of nature has displayed, for promoting the comfort and preservation of "every thing that lives."[1]

Further, *were the air coloured*, or were its particles much larger than they are, we could never obtain a distinct view of any other object. The exhalations which rise from the earth, being rendered visible, would disfigure the rich landscape of the universe, and render life disagreeable. But the Almighty, by rendering the air invisible, has enabled us not only to take a delightful and distinct survey of the objects that surround us, but has vailed from our view the gross humours incessantly perspired from animal bodies, the filth exhaled from kitchens, streets, and sewers, and every

[1] The necessity of atmospherical air for the support of life was strikingly exemplified in the fate of the unhappy men who died in the *Black-hole* of Calcutta. On the 20th of June, 1756, about eight o'clock in the evening, 146 men were forced, at the point of the bayonet, into a dungeon only 18 feet square. They had been but a few minutes confined in this infernal prison before every one fell into a perspiration so profuse that no idea can be formed of it. This brought on a raging thirst, the most difficult respiration, and an outrageous delirium. Such was the horror of their situation, that every insult that could be devised against the guard without, and all the opprobrious names that the Viceroy and his officers could be loaded with, were repeated, to provoke the guard to fire upon them, and terminate their sufferings. Before eleven o'clock the same evening one third of the men were dead; and before six next morning only 23 came out alive, but most of them in a high putrid fever. All these dreadful effects were occasioned by the want of atmospheric air, and by their breathing a superabundance of the carbonic acid emitted from their lungs.

other object that would excite disgust. Again, *were the different portions of the atmosphere completely stationary*, and not susceptible of agitation, all nature would soon be thrown into confusion. The vapours which are exhaled from the sea by the heat of the sun would be suspended, and remain for ever fixed over those places from whence they arose. For want of this agitation of the air, which now scatters and disperses the clouds over every region, the sun would constantly scorch some districts, and be for ever hid from others; the balance of nature would be destroyed; navigation, as it has hitherto been carried on by the agency of winds, would be useless, and we could no longer enjoy the productions of different climates. In fine, were the atmosphere capable of being frozen, or converted into a solid mass, as all other fluids are, (and we known no reason why it should not be subject to congelation but the will of the Creator,) the lives of every animal in the air, the waters, and the earth, would in a few moments be completely extinguished. But the admirable adjustment of every circumstance, in relation to this useful element, produces all the beneficial effects which we now experience, and strikingly demonstrates that the intelligent Contriver of all things is "wonderful in counsel and excellent in working."

From the instances now stated we may plainly perceive, that if the Almighty had not a particular regard to the happiness of his intelligent offspring, and to the comfort of every animated existence, or if he wished to inflict summary punishment on a wicked world, he could easily effect, by a very slight change in the constitution of the atmosphere, the entire destruction of the human race, and the entire conflagration of the great globe they inhabit, throughout all its elementary regions. He has only to extract one of its constituent parts—the nitrogen from the oxygen gas—and the grand catastrophe is at once accomplished. With what a striking propriety and emphasis, then, do the inspired writers declare that "in Him we live and move and have our being;" and that "in His hand is the soul of every living thing, and the breath of all mankind."

A great variety of other admirable properties is possessed by the atmosphere, of which I shall briefly notice only the following:—It is the vehicle of *smells*, by which we become acquainted with the qualities of the food which is set before us, and learn to avoid those

places which are damp, unwholesome, and dangerous. It is the medium of *sounds*, by means of which knowledge is conveyed to our minds. Its undulations, like so many couriers, run for ever backwards and forwards, to convey our thoughts to others and theirs to us; and to bring news of transactions which frequently occur at a considerable distance. A few strokes on a large bell, through the ministration of the air, will convey signals of distress or of joy in a quarter of a minute, to the population of a city containing 100,000 inhabitants. So that the air may be considered as the conveyor of the thoughts of mankind, which are the cement of society. It transmits to our ears all the harmonies of music, and expresses every passion of the soul; it swells the notes of the nightingale, and distributes alike to every ear the pleasures which arise from the harmonious sounds of a concert. It produces the blue colour of the sky, and is the cause of the morning and the evening twilight, by its property of bending the rays of light and reflecting them in all directions. It forms an essential requisite for carrying on all the processes of the vegetable kingdom, and serves for the production of clouds, rain, and dew, which nourish and fertilize the earth. In short, it would be impossible to enumerate all the advantages we derive from this noble appendage to our world. Were the earth divested of its atmosphere, or were only two or three of its properties changed or destroyed, it would be left altogether unfit for the habitation of sentient beings. Were it divested of its undulating quality, we should be deprived of all the advantages of speech and conversation, of all the melody of the feathered songsters, and of all the pleasures of music; and, like the deaf and dumb, we could have no power of communicating our thoughts but by visible signs. Were it deprived of its reflective powers, the sun would appear in one part of the sky in dazzling brightness, while all around would appear dark as midnight, and the stars would be visible at noon-day. Were it deprived of its refractive powers, instead of the gradual approach of the day and the night which we now experience—at sunrise we should be transported all at once from midnight darkness to the splendour of noon-day; and, at sunset, should make as sudden a transition from the splendours of day to all the horrors of midnight, which would bewilder the traveller in his journey, and strike the creation with amazement. In fine, were the oxygen of the atmosphere completely extracted,

destruction would seize on all the tribes of the living world throughout every region of earth, air, and sea.

Omitting, at present, the consideration of an indefinite variety of other particulars, which suggest themselves on this subject, I shall just notice one circumstance more, which has a relation both to the waters and to the atmosphere. It is a well known law of nature, that all bodies are expanded by heat, and contracted by cold. There is only one exception to this law which exists in the economy of our globe, and that is *the expansion of water in the act of freezing.* While the parts of every other body are reduced in bulk, and their specific gravity increased by the application of cold; water, on the contrary, when congealed into ice, is increased in bulk, and becomes of a less specific gravity than the surrounding water, and therefore swims upon its surface. Now, had the case been otherwise; had water, when deprived of a portion of its heat, followed the general law of nature, and, like all other bodies, become specifically heavier than it was before, the present constitution of nature would have been materially deranged, and many of our present comforts and even our very existence, would have been endangered. At whatever time the temperature of the atmosphere became reduced to 32° of the common thermometer, or to what is called the freezing point, the water on the surface of our rivers and lakes would have been converted into a layer of ice; this layer would have sunk to the bottom as it froze; another layer of ice would immediately have been produced, which would also have sunk to the former layer, and so on in succession, till in the course of time all our rivers from the surface to the bottom, and every other portion of water capable of being frozen, would have been converted into solid masses of ice, which all the heat of summer could never have melted. We should have been deprived of most of the advantages we now derive from the liquid element, and in a short time the face of nature would have been transformed into a frozen chaos. But in the existing constitution of things, all such dismal effects are prevented, in consequence of the Creator having subjected the waters to a law contrary to that of other fluids, by means of which the frozen water swims upon the surface, and preserves the cold from penetrating to any great depth in the subjacent fluid; and when the heat of the atmosphere is increased, it is exposed to its genial influence, and is quickly changed into

its former liquid state. How admirably, then, does this *exception* to the general law of nature display the infinite intelligence of the great Contriver of all things, and his providential care for the comfort of his creatures, when he arranged and established the economy of nature.

On Light

In tracing the divine wisdom and goodness, as displayed in the earth, the waters, the atmosphere, and other appendages to our globe, it may not be improper to advert for a little to the nature of LIGHT, as a striking display of the wisdom and beneficence of the Creator.

Light is that ethereal matter, distributed throughout the immensity of the universe, by which objects are rendered perceptible by our visual organs. It is by the agency of this mysterious substance that we become acquainted with the beauties and sublimities of creation, and the wonderful operations of its almighty Author. Without its influence no world could be inhabited, and no animated being could subsist in the manner it now does. Although all the bodies in the universe could be supposed to exist as they do at present, yet without *light* a universal blank would be presented to every intelligence—the "blackness of darkness" would surround them for ever, and no traces of the attributes and operations of an Almighty Being, such as we now behold, could be perceived throughout the whole system of nature. What such a state of things would be, if we could suppose intelligent beings to exist, and the universe deprived of the agency of light, it is scarcely possible for us to form a distinct conception. We have never yet known what it is to live in a world deprived of this delightful visitant; for in the darkest night we enjoy a share of its beneficial agency, and even in the deepest dungeon its influence has been felt by those unfortunate individuals whom tyranny had shut up in prison-houses deprived of the direct rays of the sun. The blind, indeed, do not *directly* enjoy the advantages of light; but its influence is reflected upon them, and their knowledge and happiness are promoted through the medium of those who have the full use of their visual organs. Were all the inhabitants of the world deprived of their eye-sight, and consequently of the agency of light, neither knowledge nor happiness, such as we now experience,

could possibly be enjoyed. An awful pause to human activity and enjoyment would instantly ensue, and a scene of confusion would be introduced among human beings, such as has never yet occurred in the history of our world.

As light is an element in the material world of so much importance, so we find that arrangements have been made by the Almighty Creator for its universal diffusion in all the systems and worlds that exist throughout the vast amplitudes of creation. In our system the sun is the grand depository of light, from which

THE SUN. SHEWING THE SPOTS.

luminary it diffuses itself over every region of our globe to cheer and animate all its inhabitants both sentient and intellectual. It also irradiates every planet connected with the Solar system, even the most remote, though moving at the distance of 1,800,000,000 of miles from its source. If the earth and the other planets, however, had no diurnal rotations, its benefits would only be partially diffused, and the one half of their surfaces would be deprived of its exhilarating and benign agency. But, in order that it may be *equably* diffused over every part of the surfaces of these globes, we

find, from observation, that they revolve round their axes, presenting alternately every portion of their surfaces to the source of light, so that the inhabitants of every region may enjoy its benefits. We are not, however, involved in absolute darkness, when the hemisphere in which we dwell is turned from the sun; for then distant luminaries shed their milder rays from the nocturnal sky, and direct our views to those far remote regions where, suns unnumbered shine, and planets and comets run their solemn rounds. Even in the darkest and most cloudy evening the influence of light from the celestial luminaries is sensibly felt, by which the traveller is enabled to trace his path, and to pass on in safety.

Another mode of diffusing light is to be found in those arrangements by which satellites or moons are made to revolve around most of the primary planets, by which a mild radiance is reflected on their surfaces in the absence of the sun. The primary planets likewise reflect an immense quantity of light upon the surfaces of their satellites. The planet Jupiter will appear to his nearest satellite like an immense globe in the heavens, about 1300 times larger than the apparent size of our moon, and will diffuse a vast quantity of light upon it. In like manner when the sun is absent from that hemisphere of the moon which is next to us, the earth shines upon it with a face 13 times larger than the moon presents to us. Another wonderful mode of diffusing light is to be found in the construction of Saturn's ring. This mighty arch will appear from the globe of Saturn, to extend across the whole heavens, having a breadth equal to 100 of our moons, and filling nearly the one-fifth of the visible sky with its lustre. All the stars which adorn the canopy of our sky may likewise be considered as so many fountains of light to irradiate numerous worlds within the sphere of their influence, as well as to illuminate and adorn the canopy of our terrestrial habitation. In short, all the arrangements of the Almighty throughout creation, so far as we have an opportunity of penetrating, appear to have this great end in view, to diffuse illumination and splendour throughout every region, and over all the bodies in the universe.

In these arrangements of the Creator we behold a striking display of divine wisdom and benevolence, and an evidence that the happiness of every rank of his creatures throughout the material system is one great object of all his designs and contrivances. For light may be considered as little less than the life and enjoy-

ment of all sensitive and intelligent beings. What advantage would it be to be partakers of life—what pleasure or comfort would it produce, were we doomed to live in all the horrors of perpetual darkness? How could we provide ourselves with food or drink, or clothing? How could we transact the least business, or hold correspondence with each other as social beings? How could we derive materials for the exercise of the mental powers or form any just conceptions of the eternal Creator?—If light were annihilated, and the universe deprived of its agency; or, what would produce the same effect, were all the animated beings connected with our globe deprived of the organs of vision, the whole world would soon be thrown into a state of complete distraction and confusion. We might lose the organs of hearing and smelling, and yet mankind might go forward from generation to generation nearly in the manner they have hitherto done. But if men and all the other animals around them were deprived of their eye-sight, this globe would be unpeopled in the course of another generation. The air would be deprived of all the winged creatures that now fly through its different regions. The seas and rivers would be deserted of all the finny tribes that now skim through their waters. Man would soon sink, in the midst of terrific gloom, into the grave. For he would be unable to cultivate the ground, to convey himself by land or water, or to carry on those transactions and intercourses which are essential to his subsistence, and even to his very existence, and all the tribes of the lower animals would be unable to search for that food on which their existence depends; and, ere long, this huge globe on which we tread would become *one vast sepulchre*, without life or animation.

But now, in the existing constitution of things—through the medium of light—we can go with safety here and there, wherever pleasure or duty calls; we can transact every kind of business by day, and by means of artificial light by night. Light unfolds to us the expansive scenes of the universe, and the perfections of its Author as displayed in its structure and arrangements. It opens to our view the magnificence and glories of the heavens—the continents, islands, and oceans—the beauties of the flowery fields—the gay attire of the feathered tribes—the grand and beautiful landscapes with which most countries are adorned, and enables us to traverse every land, and to convey ourselves across oceans

and continents to the "uttermost ends of the earth." All creatures and objects, from the microscopic animalcule to the magnificent globes which roll above us in the distant regions of creation, are laid open to our view through the medium of light. The property which it has of being refracted and reflected, and of forming images of objects when passing through lenses or reflected from mirrors, has enabled us to contrive telescopes by which objects in the heavens far beyond the reach of the unassisted eye may be distinctly perceived—and microscopes which have brought to view the latent beauties of the animal and vegetable kingdoms, and living beings, 100,000 times less than a visible point.—In short, it appears evident that that almighty Being "who dwells in light inaccessible" has diffused light over the remotest spaces of creation, in order that every intellectual being, wherever existing, may feel its beneficent effects, and be enabled, through its agency, to trace his wonderful operations, and the attributes with which he is invested. And, therefore we have every reason to believe, that, could we fly with the swiftness of an archangel, for thousands of years, through the regions of immensity, we should never approach a region of absolute darkness, but should find ourselves every moment encompassed with the emanations of light, and cheered with its benign influence.

But it may be asked what is the *nature* of that substance we call *light*, which acts so important a part in the economy of nature? On this point there have been different opinions. It is either a subtile matter that fills the whole sphere of the universe, and receives from luminous bodies an impulse or agitation which is incessantly continued, and which, by its vibratory motion enables us to perceive the objects of the visible creation—Or, it is the emission or emanation of the particles of luminous bodies thrown out incessantly in every direction. But although we can say little decisively respecting its nature, we are acquainted with many of its properties.—It radiates from luminous bodies in *straight lines:* It moves with *amazing velocity,* at the rate of nearly 12,000,000 of miles in a minute, which is more than 1,000,000 times swifter than a cannon ball flying with its utmost velocity. And in this rapid motion the wisdom of God is remarkably displayed. For if its motion were no swifter than a cannon ball, it would take more than 30 years in its progress from the sun to the earth, in which

case its vigour and energy would be impaired, its rays would be less penetrating, and darkness would be dissipated with greater difficulty. But in consequence of its prodigious velocity, it flies in a few minutes to distant worlds, penetrates every corner of creation, and secures to us every moment its cheering and beneficial influences.—Its particles are almost *infinitely small;* and in this circumstance, too, the Divine wisdom is displayed. For, if the particles of light were only the 1,000,000th part of a small grain of sand—when we consider their prodigiously rapid motion—every object on which they struck would be battered and perforated, till our globe were laid in ruins, and every living being destroyed.—Again, light issues forth *in all directions* from every visible point of luminous bodies. Hence it follows, that the sun illuminates, in the Solar system, not only an immense *plane,* extending along the paths of the planets, from the one side of the orbit of Uranus to the other, but the whole of that sphere, or *solid space,* of which the distance of Uranus is the radius, and fills every point of it with his rays.—Light, though extremely minute, has been considered, from certain experiments, as having a certain degree of *force* or *momentum.* From calculations founded on these experiments, it has been concluded, that although the particles of light be considered as continually emanating from the sun, before his diameter could be shortened ten miles by this waste of his substance, it would require a period to elapse of above 31,000,000 of years.

The effect of light on the eye is not instantaneous, but continues for a short space of time, especially when it proceeds from very bright objects.—Its intensity is diminished in proportion to the square of the distance from the luminous body.—It is by light reflected from opake bodies that most of the objects around us and also the moon and planets in the heavens are rendered visible.—It is light which produces all the variegated *colouring* which we behold on all the different objects which compose a terrestrial landscape, without which they could not be distinguished. To this agent the flowers owe all their beauties, and the trees and shrubs their verdure. It is found that the green colour of all plants depends entirely on the solar light being allowed to shine upon them; for without the influence of the sun's rays they are always of a *white colour.* Experiments have been tried to ascertain whether a constant and strong light from a great number of lamps kept

continually burning might have the same effect as the day light, but the plants remained quite colourless as those growing in the dark. The greater part of living vegetables incline their stems toward the light. Most of the discous flowers follow the sun in his course; they attend him in his evening retreat, and meet his rising lustre in the morning with the same unerring law. They unfold their flowers on the approach of this luminary; they follow his course by turning on their stems, and close them as soon as he disappears. The refractions and reflections to which light is subjected in our terrestrial sphere present a variety of sublime and beautiful effects, and lead us to form some conceptions of the magnificent and diversified scenes which it may produce in other systems and worlds under the arrangements of the all-wise and beneficent Creator.

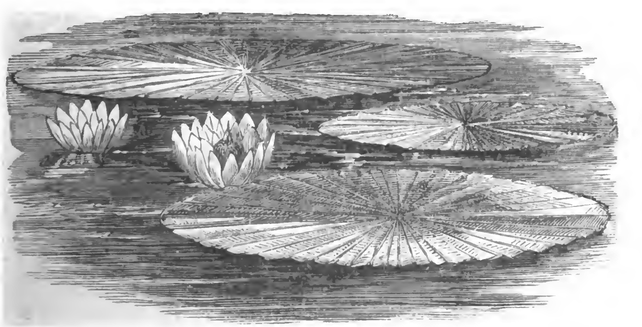
Such are some of the properties and effects of light. Of all the objects which present themselves to the philosophic and contemplative mind light is one of the noblest and most interesting. The action it exerts on all the combinations of matter, and the office it performs in what constitutes the life and enjoyment of all organized beings, lead us to consider it as a substance acting the first part in the economy of nature. It unfolds to our view the sublime spectacle of the universe. It gives animation, beauty, and sublimity to every surrounding scene. It is universal in its movements and in its influence. It wings its way, from the solar orb, through the voids of space, along a course of 95,000,000 of miles till it arrive at the outskirts of our globe. It passes freely through the surrounding atmosphere; it strikes upon the clouds and is reflected by them; it irradiates the mountains, the vales, the forests, the rivers, the seas, and all the vegetable tribes, and adorns them with a countless assemblage of colours. It flies without intermission from star to star, and from suns to planets, throughout the boundless sphere of immensity, forming a connecting chain and a medium of communication among all the worlds within the wide empire of Omnipotence.—In short, it is the symbol of the Divinity himself; for "God is light, and in him is no darkness at all." "He covereth himself with light as with a garment, and dwells in light inaccessible and full of glory." It is a representative of Him who is exhibited in the sacred oracles as "The Sun of Righteousness," and "The Light of the world." It is an emblem of the glories and felicities of that future world where knowledge shall

be perfected and happiness complete; for its inhabitants are designated "The saints in light;" and Scripture declares it to have been the first born of created beings—essential to the happiness of every creature that might afterwards be brought into existence.

Variety of Nature.

As a striking evidence of divine intelligence, we may next consider the *immense variety which the Creator has introduced into every department of the material world.*

In every region on the surface of the globe, an endless multiplicity of objects, all differing from one another in shape, colour, and motion, present themselves to the veiw of the beholder. Mountains covered with forests, hills clothed with verdure, spacious plains adorned with vineyards, orchards, and waving grain; naked rocks, abrupt precipices, extended vales, deep dells, meandering rivers, roaring cataracts, brooks and rills, lakes and gulfs, bays and promontories, seas and oceans, caverns and grottoes—meet the eye of the student of nature, in every country, with a variety which is at once beautiful and majestic. Nothing can exceed the variety of the *vegetable kingdom,* which pervades all climates, and



THE VICTORIA REGINA, THE LARGEST PLANT, IN FLOWER.

almost every portion of the dry land, and of the bed of the ocean. The immense collections of Natural History which are to be seen in the museum at Paris show, that botanists are already

acquainted with nearly 56,000 different species of plants.[1] And yet it is probable that these form but a very small portion of what actually exists, and that several hundreds of thousands of species remain to be explored by the industry of future ages: for by far the greater part of the vegetable world still remains to be surveyed by the scientific botanist. Of the numerous tribes of vegetable nature which flourish in the interior of Africa and America, in the immense islands of New Holland, New Guinea, Borneo, Sumatra, Javo, Ceylon, Madagascar, and Japan: in the vast regions of Tartary, Tibet, Siberia, and the Birman empire, in the Philippines, the Moluccas, the Ladrones, the Carolinas, the Marquesas, the Society, the Georgian, and in thousands of other islands which are scattered over the Indian and Pacific oceans—little or nothing is known by the naturalists of Europe; and yet it is a fact which admits of no dispute that every country hitherto explored produces a variety of species of plants peculiar to itself; and those districts in Europe which have been frequently surveyed present to every succeeding explorer a new field of investigation, and reward his industry with new discoveries of the beauties and varieties of the vegetable kingdom. It has been conjectured by some naturalists, on the ground of a multitude of observations, that "there is not a square league of earth but what presents some one plant peculiar to itself, or at least which thrives there better or appears more beautiful than in any other part of the world." This would make the number of species of vegetables to amount to as many millions as there are of square leagues on the surface of the earth—that is, to more than 21,000,000.

Now every one of these species of plants differs from another in its size, structure, form, flowers, leaves, fruits, mode of propagation, colour, medicinal virtues, nutricious qualities, internal vessels, and the odour it exhales. They are of all sizes, from the microscopic mushroom, invisible to the naked eye, to the sturdy oak and the cedar of Lebanon, and from the slender willow to the Banian tree, under whose shade 7000 persons may find ample room to repose. A thousand different shades of colour distinguish the different species. Every one wears its peculiar livery, and is distinguished by its own native hues; and many of their inherent beauties can be distinguished only by the help of the microscope.

[1] Edinburgh Philosophical Journal, July, 1822, p. 48.

Some grow upright, others creep along in a serpentine form. Some flourish for ages, others wither and decay in a few months; some spring up in moist, others in dry soils; some turn towards the sun, others shrink and contract when we approach to touch them. Not only are the different species of plants and flowers distinguished from each other by their different forms, but even the different individuals of the same species. In a bed of tulips or carnations, for example, there is scarcely a flower in which some difference may not be observed in its structure, size, or assemblage of colours; nor can any two flowers be found in which the shape and shades are exactly similar. Of all the hundred thousand millions of plants, trees, herbs, and flowers, with which our globe is variegated, there are not, perhaps, two individuals precisely alike in every point of view in which they may be contemplated; yea there is not perhaps a single leaf in the forest, when minutely examined, that will not be found to differ, in certain aspects, from its fellows; such is the wonderful and infinite diversity with which the Creator has adorned the vegetable kingdom.

His wisdom is also evidently displayed in this vast profusion of vegetable nature—in adapting each plant to the soil and situation in which it is destined to flourish—in furnishing it with those vessels by which it absorbs the air and moisture on which it feeds—and in adapting it to the nature and necessities of animated beings. As the earth teems with animated existence, and as the different tribes of animals depend chiefly on the productions of the vegetable kingdom for their subsistence, so there is an abundance and a variety of plants adapted to the peculiar constitution of every individual species. This circumstance demonstrates that there is a precontrived relation and fitness between the internal *constitution* of the animal, and the *nature of the plants* which afford it nourishment; and show us that the animal and the vegetable kingdoms are the workmanship of *one* and the same almighty Being, and that, in his arrangements with regard to the one, he had in view the necessities of the other.

When we direct our attention to the tribes of *animated nature*, we behold a scene no less variegated and astonishing. Above 50,000 species of animals have been detected and described by naturalists, besides several thousands of species which the naked eye cannot discern, and which people the invisible regions of the

waters and the air. And as the greater part of the globe has never yet been thoroughly explored, several hundreds if not thousands of species unknown to the scientific world may exist in the depths of the ocean, and in the unexplored regions of the land. All these species differ from one another in colour, size, and shape; in the internal structure of their bodies, in the number of their sensitive organs, limbs, feet, joints, claws, wings, and fins; in their dispositions, faculties, movements, and modes of subsistence. They are of all sizes, from the mite and the gnat up to the elephant and the whale, and from the mite downwards to those invisible animalcules, 100,000 of which would not equal a grain of sand. Some fly through the atmosphere, some glide through the waters, others traverse the solid land. Some walk on 2, some on 4, some on 20, and some on a 100 feet. Some have eyes furnished with 2, some with 8, some with a 100, and some with 8000 distinct transparent globes, for the purposes of vision.[1]

MAGNIFIED ANIMALCULÆ.

Our astonishment at the variety which appears in the animal kingdom is still further increased when we consider not only the

[1] The *eyes* of beetles, silk worms, flies, and several other kinds of insects, are among the most curious and wonderful productions of the God of nature. On the head of a fly are two large protuberances, one on each side; these constitute its organs of vision. The whole surface of these protuberances is covered with a multitude of small hemispheres, placed with the utmost regularity in rows, crossing each other in a kind of lattice work. These little hemispheres have each of them a minute transparent convex lens in the middle, each of which has a distinct branch of the optic nerve ministering to it; so that the different lenses may be considered as so many distinct eyes. Mr. Leeuwenhoek counted 6236 in the two eyes of a silk worm, when in its *fly* state; 3180 in each eye of a bettle; and 8000 in the two eyes of the *common fly*. Mr. Hooke reckoned 14,000 in the eyes of a

diversities which are apparent in their external aspect, but also in their internal structure and organization. When we reflect on the thousands of movements, adjustments, adaptations, and compensations, which are requisite in order to the construction of an animal system, for enabling it to perform its intended functions;—when we consider, that every species of animals has a system of organization peculiar to itself, consisting of bones, joints, blood vessels, and muscular motions, differing in a variety of respects from those of any other species, and exactly adapted to its various necessities and modes of existence;—and when we consider still further, the incomprehensibly delicate contrivances, and exquisite borings, polishings, claspings, and adaptations, which enter into the organization of an animated being ten thousand times less than a mite; and that the different species of these animals are likewise all differently organised from one another,—we cannot but be struck with reverence and astonishment at the *intelligence* of that incomprehensible Being who arranged the organs of all the tribes of animated nature, "who breathed into them the breath of life," and who continually upholds them in all their movements!

Could we descend into the subterraneous apartments of the globe, and penetrate into those unknown recesses which lie towards its centre, we should doubtless behold a variegated scene of wonders even in those dark and impenetrable regions. But all the labour and industry of man have not hitherto enabled him to penetrate farther into the bowels of the earth than the 6000th part of its

drone fly; and, in one of the eyes of a *dragon fly,* there have been reckoned 13,500 of these lenses, and consequently, in both eyes 27,000, every one of which is capable of forming a distinct image of any object, in the same manner as a common convex glass; so that there are 27,000 images formed on the retina of this little animal. Mr. Leeuwenhoek having prepared the eye of a fly for the purpose, placed it a little farther from his microscope than when he would examine an object, so as to leave a proper focal distance between it and the lens of his microscope; and then he looked through both, in the manner of a telescope, at the steeple of a church, which was 299 feet high, and 750 feet distant, and could plainly see through every little lens, the whole steeple inverted, though not larger than the point of a fine needle; and then directing it to a neighbouring house, saw through many of these little hemispheres, not only the front of the house, but also the doors and windows, and could discern distinctly whether the windows were open or shut—such an exquisite piece of Divine mechanism transcends all human comprehension.

diameter, or about a mile and a quarter; so that we must remain for ever ignorant of the immense caverns and masses of matter that may exist, and of the processes that may be going on, about its central regions. In those regions, however, near the surface, which lie within the sphere of human inspection, we perceive a variety analogous to that which is displayed in the other departments of nature. Here we find substances of various kinds formed into strata, or layers of different depths—earth, sand, gravel, marl, clay, sandstone, freestone, marble, limestone, coals, peat, and similar materials. In these strata are found metals and minerals of various descriptions—salt, nitrate of potash, ammonia, sulphur, bitumen, platina, gold, silver, mercury, iron, lead, tin, copper, zinc, nickel, manganeze, cobalt, antimony, the diamond, rubies, sapphires, jaspers, emeralds, and a countless variety of other substances of incalculable benefit to mankind. Some of these substances are so essentially requisite for the comfort of man that without them he would soon degenerate into the savage state, and be deprived of all those arts which extend his knowledge, and which cheer and embellish the abodes of civilized life.

If we turn our eyes upward to the regions of the atmosphere, we may also behold a spectacle of variegated magnificence. Sometimes the sky is covered with sable clouds, or obscured with mists; at other times it is tinged with a variety of hues, by the rays of the rising or the setting sun. Sometimes it presents a pure azure, at other times it is diversified with strata of dappled clouds. At one time we behold the rainbow rearing its majestic arch, adorned with all the colours of light; at another, the Aurora Borealis illuminating the sky with its fantastic coruscations. At one time we behold the fiery meteor sweeping through the air, diffusing a sparkling and brilliant light; at another, we perceive the forked lightning darting from the clouds, and hear the thunders rolling through the sky. Sometimes the vault of heaven appears like a boundless desert, particularly about the time of the rising and setting of the sun in a clear sky; and at other times adorned with an innumerable host of stars, the blazing comet, the planets in their courses, and with the moon "walking in brightness." In short, whether we direct our view to the vegetable or the animal tribes—to the atmosphere, the ocean, the mountains, the plains, or the subterranean recesses of the globe, we behold a scene of beauty, order, and

variety, which astonishes and enraptures the contemplative mind, and constrains us to join in the devout exclamations of the Psalmist, "*How manifold are thy works*, O Lord! In wisdom hast thou made them all: the earth is full of thy riches; so is the great and wide sea, wherein are things creeping *innumerable*, both small and great beasts."

This countless variety of objects which appears throughout every department of our sublunary system, not only displays the depths of divine wisdom, but also presents us with a faint idea of the *infinity* of the Creator, and of the *immense multiplicity of ideas and conceptions* which must have existed in the eternal mind when the fabric of our globe, and its numerous tribes of inhabitants, were arranged and brought into existence. And if every other world which floats in the immensity of space be diversified with a similar variety of existences, altogether different from ours, (as we have reason to believe, from the variety we already perceive, and from the boundless plans and conceptions of the Creator,) the human mind is lost and confounded when it attempts to form an idea of those endless diversified plans, conceptions, and views, which must have existed during an eternity past in the divine mind. When we would attempt to enter into the conception of so vast and varied operations, we feel our own littleness, and the narrow limits of our feeble powers, and can only exclaim, with the apostle Paul, "O the depth of the riches both of the wisdom and knowledge of God! how unsearchable are his counsels, and his ways (of creation and providence) past finding out!"

This characteristic of variety, which is stamped on all the works of Omnipotence, is doubtless intended to gratify the principle of curiosity, and the love of novelty, which are implanted in the human breast; and thus to excite rational beings to the study and investigation of the works of the Creator; that therein they may behold the glory of the divine character, and be stimulated to the exercise of love, admiration, and reverence. For, as the records of Revelation and the dispensations of Providence display to us the various aspects of the moral character of Deity, so the diversified phenomena, and the multiplicity of objects and operations which the scenery of nature exhibits, present to us a specimen of the *ideas*, as it were, of the eternal mind, in so far as they can be shadowed forth by material objects, and exhibited to mortals through the medium of corporeal organs.

To convey an adequate conception of the *number* of these ideas, as exhibited on the globe on which we live, would baffle the arithmetician's skill, and set his numbers at defiance. We may, however, assist our conceptions a little by confining our attention to one department of nature; for example, the ANIMAL KINGDOM. The number of the different species of animals, taking into account those which are hitherto undiscovered, and those which are invisible to the naked eye, cannot be estimated at less than 300,000. In a human body there are reckoned about 446 muscles, in each of which, according to anatomists, there are at least 10 several intentions or due qualifications to be observed—its proper figure, its just magnitude, the right disposition of its several ends, upper and lower, the position of the whole, the insertion of its proper nerves, veins, arteries, etc., so that, in the muscular system alone, there are 4460 several ends or aims to be attended to.—The bones are reckoned to be in number about 245, and the distinct scopes or intentions of each of these are above 40; in all, about 9800: so that the system of bones and muscles alone, without taking any other parts into consideration, amounts to above 14,000 different intentions or adaptations. If now we suppose, that all the species of animals above stated are differently constructed, and, taken one with another, contain, at an average, a system of bones and muscles as numerous as in the human body—the number of species must be multiplied by the number of different aims or adaptations, and the product will amount to 4,200,000,000. If we were next to attend to the many thousands of blood vessels in an animal body, and the numerous ligaments, membranes, humours, and fluids of various descriptions, the skin with its millions of pores, and every other part of an organical system, with the aims and intentions of each, we should have another sum of many hundreds of millions to be multiplied by the former product, in order to express the diversified ideas which enter into the construction of the animal world. And if we still further consider that, of the hundreds of millions of individuals belonging to each species, no two individuals exactly resemble each other—that all the myriads of vegetables with which the earth is covered are distinguished from each other by some one characteristic or another, and that every grain of sand contained in the mountains and in the bed of the ocean, as shown by the microscope, discovers a different form and configura-

VARIETY OF NATURE.

tion from another—we are here presented with an *image* of the *infinity* of the *conceptions* of Him in whose incomprehensible mind they all existed, during countless ages, before the universe was formed.

To overlook this amazing scene of divine intelligence, or to consider it as beneath our notice, as some have done, if it be not the characteristic of impiety, is at least, the mark of a weak and undiscriminating mind. That man who disregards the visible displays of infinite wisdom, or who neglects to investigate them when opportunity offers, acts as if he considered himself already possessed of a sufficient portion of intelligence, and stood in no need of such sensible assistance to direct his conceptions of the Creator. Pride, and false conceptions of the nature and design of true religion, frequently lie at the foundation of all that indifference and neglect with which the visible works of God are treated by those who make pretensions to a high degree of spiritual attainments. The truly pious man will trace, with wonder and delight, the footsteps of his Father and his God wherever they appear in the variegated scene of creation around him, and will be filled with sorrow and contrition of heart, that, amidst his excursions and solitary walks, he has so often disregarded "the works of the Lord, and the operation of his hands."

In fine, the variety which appears on the face of nature not only enlarges our conceptions of infinite wisdom, but is also the foundation of all our discriminations and judgments as rational beings, and is of the most essential utility in the affairs of human society. Such is the variety of which the features of the human countenance are susceptible, that it is probable, that no two individuals, of all the millions of the race of Adam that have existed since the beginning of time, would be found to resemble each other. We know no two human beings presently existing, however similar to each other, but may be distinguished either by their stature, their forms, or the features of their faces; and on the ground of this dissimilarity, the various wheels of the machine of society move onward, without clashing or confusion. Had it been otherwise—had the faces of men, and their organs of speech, been cast exactly in the same mould, as would have been the case had the world been framed according to the Epicurean system, by blind chance directing a concourse of atoms, it might have been as difficult to

distinguish one human countenance from another, as to distinguish the eggs laid by the same hen, or the drops of water which trickle from the same orifice: and consequently, society would have been thrown into a state of universal anarchy and confusion. Friends would not have been distinguished from enemies, villains from the good and honest, fathers from sons, the culprit from the innocent person, nor the branches of the same family from one another. And what a scene of perpetual confusion and disturbance would thus have been created. Frauds, thefts, robberies, murders, assassinations, forgeries, and injustice of all kinds, might have been daily committed without the least possibility of detection. Nay, were even the *variety of tones* in the human voice, peculiar to each person, to cease, and the *handwriting* of all men to become perfectly uniform, a multitude of distressing deceptions and perplexities would be produced in the domestic, civil, and commercial transactions of mankind. But the all-wise and benificent Creator has prevented all such evils and inconveniences by the character of *variety* which he has impressed on the human species, and on all his works. By the peculiar features of his countenance every man may be distinguished in the light; by the tones of his voice he may be recognised in the dark, or when he is separated from his fellows by an impenetrable partition; and his handwriting can attest his existence and individuality when continents and oceans interpose between him and his relatives, and be a witness of his sentiments and purposes to future generations.

Thus I have taken a very cursory view of some evidences of divine wisdom which appear in the general constitution of the *earth*, the *waters*, and the *atmosphere*, and in the characteristic of *variety* which is impressed on all the objects of the visible creation. When these and other admirable arrangements in our sublunary system are seriously contemplated, every rational and pious mind will be disposed to exclaim with the Psalmist, "There is none like unto thee, O Lord, neither are there any works like unto thy works." "Thou art great, and doest wondrous things: thou art God alone." "O that men would praise the Lord for his goodness and for his wonderful works towards the children of men!"

When we consider not only the *utility*, but the *beauty* and *grandeur* of the wise arrangements of nature, what reason have we to admire and adore the goodness of the great Author of our existence? Were all the diversities of shape and colour, of mountains and vales, of rivers and lakes, of light and shade, which now embellish the various landscapes of the world, to disappear, and were one unvaried scene perpetually to present itself to the eye, how dull and wearisome and uninteresting would the aspect of the universe appear to an intelligent mind? Although the variegated beauties which adorn the surface of our globe and the vault of heaven are not essential to our existence as sensitive beings, yet were they completely withdrawn, and nothing presented to the eye but a boundless expanse of barren sands, the mind would recoil upon itself, its activity would be destroyed, its powers would be confined, as it were, to a prison, and it would roam in vain amidst the surrounding waste in search of enjoyment. Even the luxuries of a palace, were it possible to procure them amidst such a scene of desolation, would become stale and insipid, and would leave the rational soul, almost destitute of ideas and of mental energy, to the tiresome round of a cheerless existence. But, in the actual state of the world we live in, there is no landscape in nature, from the icebergs of Greenland to the verdant scenes of the torrid zone, in which objects, either of sublimity or of beauty, in boundless variety, are not presented to the view, in order to stimulate the mind to activity, to gratify its desire of novelty, and to elevate its conceptions of the beneficent Creator.

And if the present constitution of our world displays so evident marks of beauty and benevolent design, now that it is inhabited by an assemblage of depraved intelligencies, and its physical aspect deformed in consequence of the "wickedness of man," what transporting beauties and sublimities must it have presented when it appeared fresh from the hand of its almighty Maker, and when all things were pronounced by him to be very *good!* After a deluge of waters has swept away many of its primeval beauties, and has broken and deranged even its subterraneous strata, this terrestrial world still presents to the eye a striking scene of beauty, order, and beneficence. But we have the strongest reason to believe that, before sin had disfigured the aspect of this lower world, all was "beauty to the eye and music to the ear,"—that "immor-

tality breathed in the winds, flowed in the rivers," and exhaled from every plant and flower. No storms disturbed the tranquillity of nature, nor created the least alarm in the breasts of its holy inhabitants. No earthquakes shook the ground, nor rent the foundations of nature. No volcanoes vomited their rivers of lava, nor overwhelmed the plains with deluges of fire. No barren deserts of heath and sand disfigured the rich landscape of the world; no tempests nor hurricanes tossed the ocean, nor scorching heats nor piercing colds, nor pestilence nor disease, annoyed the human frame. In the paradisiacal state of the world, we may reasonably suppose that all the elements of nature contributed directly to the pleasure and enjoyment of man and of the other tribes of animated nature; and that they were not subjected, as they now are, to the operation of those natural agents which so frequently spread destruction and ruin among the abodes of men. To suppose the contrary to have happened would be inconsistent with the state of pure and happy intelligencies and with the benignity of the Creator; and would imply that God was either unwilling or unable to remove such physical evils. But we cannot suppose it beyond the limits of infinite wisdom and omnipotence to create and arrange a world entirely free from those evils and inconveniences which now flow from the operation of certain physical agents, without at the same time supposing that his power and intelligence are confined within certain bounds, beyond which they cannot pass. And therefore, if, in the existing constitution of things, the harmony of nature is occasionally disturbed, and its beauty defaced, by earthquakes, storms, and tempests—we must remember that the inhabitants of the earth are now a depraved race of mortals, no longer adorned with primeval purity and innocence; and that the physical economy of our globe has undergone a certain derangement, corresponding to the *moral state* of its present occupants. But since this earth, even in its present state of degradation and derangement, presents to the view of every beholder so many objects of beauty and magnificence, and so numerous traces of divine beneficence, we may reasonably conclude that scenes of divine wisdom and goodness far more glorious and transporting must be displayed in those worlds where moral evil has never shed its malign influence, and where the inhabitants—superior to disease and death—bask for ever in the regions of immortality. And

therefore, however admirable the displays of divine wisdom may appear in the sublunary scene around us, they must be considered as inferior to those which are exhibited in many other provinces of Jehovah's empire, in so far as they are blended with those physical derangements which indicate his displeasure against the sins of men.

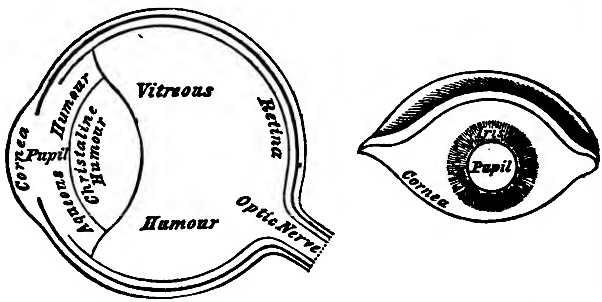
Were we now to direct our attention to the mechanism of animated beings, and to consider the numberless contrivances and adaptations in their original structure and functions, a thousand instances of exquisite wisdom and design, still more striking and admirable, would crowd upon our view. For, although the general fabric of the world, and the immense variety of objects it contains, are evident proofs of a wise and intelligent Contriver, yet it is chiefly in the minute and delicate contrivances of organical structures, their adaptation to the purposes of life, motion, and enjoyment, and their relation and correspondence to the surrounding elements, that the consummate skill of the great Architect of nature is most strikingly perceived. But as it forms no part of my present plan to enter on so extensive a field of illustration, on which volumes might be written, I shall content myself with merely stating an example or two. My first example shall be taken from

The Structure of the Human Eye.

The eye is one of the nicest pieces of mechanism which the human understanding can contemplate; but as it requires a knowledge of its anatomical structure, and of the principles of optics, to enable us to appreciate its admirable functions, I shall confine myself to a few *general* descriptions and remarks.

The eye is nearly of a globular form. It consists chiefly of three *coats* and three *humours*. The first or outer coat is termed *sclerotica;* it is every where white and opake, and is joined, at its anterior edge, to another, which is exceedingly transparent, called the *cornea,* which has more convexity than any other part of the globe of the eye. These two parts are perfectly different in their structure, and are supposed, by some anatomists, to be as distinct from each other as the glass of a watch is from the case into which it is

fixed. Next within this coat is that called the *choroides*, on account of its being furnished with a great number of vessels. It serves, as it were, for a lining to the other, and is joined with that part of the eye termed the *iris*. The *iris* is an opake membrane like the choroides, but of different colours in different eyes, as gray, black, or hazel. It is composed of two sets of muscular fibres, the one



SECTION AND FRONT VIEW OF THE EYE.

of a circular form, called the *pupil*, which contracts the hole in the middle when the light is too strong for the eye; and the other of radial fibres, tending every where from the circumference of the iris towards the middle of the pupil; which fibres, by their contractions, dilate and enlarge the pupil, when the light is weak, in order to let in more of its rays. The third coat is called the *retina*, upon which are painted the images of all visible objects, by the rays of light which flow from them. It spreads like network all over the inside of the choroides, and is nothing more than a fine expansion of the optic nerve; by which nerves the impressions of visible objects are conveyed to the brain.

The inside of the globe of the eye within these tunics or coats is filled with three humours called the aqueous, the crystalline, and the vitreous. The *aqueous* humour lies at the fore part of the eye, and occupies all the space between the crystalline and the prominent cornea. It has the same specific gravity and refractive power as water, and seems chiefly of use to prevent the crystalline from being easily bruised by rubbing or by a blow; and perhaps

it serves for the crystalline humour to move forward in while we view near objects; and backward for remoter objects; without which, or some other mechanism effecting the same purpose, we could not, according to the law of optics, perceive objects distinctly when placed at different distances. Behind the aqueous lies the *crystalline* humour, which is shaped like a double convex glass, and is a little more convex on the back than on the fore part. This humour is transparent like crystal, is nearly of the consistence of hard jelly, and converges the rays which pass through it from visible objects to its focus at the bottom or back part of the eye. The *vitreous* humour lies behind the crystalline, and fills up the greater part of the orb of the eye, giving it a globular shape. It is nearly of the consistence of the white of an egg, and very transparent; its fore part is concave, for the crystalline humour to lodge in, and the retina is spread over the back part, which is convex. It serves as a medium to keep the crystalline humour and the retina at a due distance. From what has been now stated, it is obvious that the images of external objects are depicted on the retina in an inverted position, in the same manner as the images formed by a common convex lens; but how the mind in this case perceives objects erect is a question about which the learned have been divided in their opinions.[1]

The ball of the eye, as now described, is situated in a bony cavity, called its orbit, composed by the junction of 7 different bones, hollowed out at their edges. This cavity is, in all the vacant spaces, filled with a loose fat, which serves as a proper medium for the eye to rest in, and as a socket in which it may move. It is sheltered by the eyebrows, which are provided with hair, to prevent the descending sweat of the forehead from running down into it. As a still further protection to this delicate organ, it is furnished with the eyelid, which, like a curtain, is drawn over it with inconceivable swiftness, for its security on the approach of danger. It also serves to wipe from it superfluous moisture, and to cover it during sleep. In the upper part of its orbit it is furnished with a

[1] An idea of the relative position of the *coats* and *humours* described above, may be obtained by a simple inspection of the Engraving, page 110.
It also represents a *front view* of the human eye, as it appears in its natural state, and exhibits the relative positions of the *Cornea, Iris,* and *Pupil.*

gland, to supply it with water sufficient to wash off dust, and to keep its outer surface moist, without which the cornea would be less transparent, and the rays of light would be disturbed in their passage; and the superfluous water is conveyed to the nose through a perforation in the bone.

For the purpose of enabling the eye to move in its socket, *six muscles* are provided. These are admirably contrived to move it in every direction, upwards or downwards, to the right or to the left, or in whatever direction the occasion may require; and thus we are spared the trouble of turning our heads continually towards the objects we wish to inspect. If we want to look upward, one of these muscles lifts up the orb of the eye; if we would cast our eyes to the ground, another muscle pulls them down. A third muscle moves the globe outwards towards the temples, and a fourth draws it towards the nose. A fifth, which slides within a cartilaginous ring, like a cord over a pulley, and is fastened to the globe of the eye in two points, makes it roll about at pleasure. A sixth lies under the eye, and is designed to temper and restrain within proper bounds the action of the rest, to keep it steadily fixed on the object it beholds, and to prevent those frightful contortions which otherwise might take place.[1] By these, and a multitude of other mechanical contrivances, all acting in harmonious combination, the eye, as a natural telescope and microscope, is made to advance, to recede, to move to the right and to the left, and in every other direction; and to view near and distant objects with equal distinctness; so that a single eye, by the variety of positions it may assume, performs the office of a thousand.[2]

The utility of these several movements, and the pain and inconvenience which would be suffered were any of them awanting, can scarcely be conceived by any one whose eyes have always remained in a sound state. We are so much accustomed to the regular exercise of our visual organs that we seldom reflect on the numerous delicate springs which must be set in action before the functions of vision can with ease be performed. But were any one of

[1] A more particular description of the muscles of the eye, illustrated by two engravings will be found in the author's volume entitled, 'The Improvement of Society by the Diffusion of Knowledge.' pp. 247, 248.

[2] Flies and other insects, whose eyes are immovable, have several thousands of distinct globes in each eye. See Note, pp. 100, 101.

the muscular organs now described to fail in its functions, we should soon experience so many inconveniences as would throw a gloom on all the other comforts of life; and convince us how much we are indebted every moment to the provident care and goodness of our beneficent Creator, for thousands of enjoyments which we seldom think of, and for which we are never sufficiently grateful. "With much compassion, as well as astonishment, at the goodness of our loving Creator," says Dr. Nieuwentyt, "have I considered the sad state of a certain gentleman, who, as to the rest, was in pretty good health, but only wanted the use of those two little muscles that serve to lift up the eyelid, and so had almost lost the use of his sight—being forced, as long as this defect lasted, to shove up his eyelids every moment with his own hands." [1]

How admirable, then, is the formation of the eye, and how grateful ought we to feel at the consideration, that we are permitted to enjoy all the transporting pleasures of vision, without the least perplexity or effort on our part! If the loss of action in a single muscle produces so many distressing sensations and efforts, what would be the consequence if all the muscles of the eye were awanting or deranged? And is it man that governs these nice and intricate movements; or is it the eye itself, as a self-directing machine, that thus turns round, seasonably and significantly, towards every visible object? Man knows neither the whole structure of the organs of vison, nor the functions they ought to perform. The eye is only an unconscious machine in the hands of a superior intelligence, as a watch or a steam-engine is in the hands of a mechanic. It is God alone who constantly performs its movements, according to certain laws, which he has submitted to our inclinations and desires; *"for in him we live and move."* We are *desirous* to see certain objects around us: this is all the share we have in the operations of our eyes; and without perplexing our understanding, without the least care or management in regard to any of the functions, we can, in a few moments, take a survey of the beauties and sublimities of an extensive landscape, and of the glories of the vault of heaven. Thus the divine Being operates, not only in this but in a thousand different ways, in the various senses and contrivances which belong to our animal system; and yet thought-

[1] Nieuwentyt's Religious Philosopher, vol. i, p. 232.

less and ungrateful man often enquires, in the language of doubt and hesitation, "Where is God my Maker?"—He is in us and around us, directing every movement in our animal frame to act in harmony with the surrounding elements, and to minister to our enjoyment; and it is only when his exquisite operations are deranged by external violence, or by vicious or imprudent habits, that we feel inconvenience or pain.

Such are only a few general outlines of the structure of the eye; for no notice has been taken of the numerous minute veins, arteries, nerves, lymphatics, glands, and many other particulars which are connected with this organ. But all this delicate and complicated apparatus in the structure of the eye would have been of no use whatever for the purpose of vision, had not a distinct substance been created to act upon it, exactly adapted to its nature and functions. In order that the eye might serve as the medium of our perceptions of visible objects, *light* was formed, and made to travel from its source at the rate of 192,000 miles in a second of time. This prodigious velocity of light is doubtless essential to the nature of vision; since it actually exists, and since we find that it radiates with the same swiftness from the most distant visible star, as from the sun which enlightens our system. To abate the force of this amazing velocity, its particles have been formed almost infinitely small; a circumstance which alone prevents this delightful visitant from becoming the most tremendous and destructive element in nature. Dr. Nieuwentyt has computed that, in one second of time, there flow 418,660,000,000,000,000,000,000,000,000,000,000,000,000,000,000 (that is, four hundred and eighteen septillions, six hundred and sixty sextillions,)[1] particles of light out of a burning candle, which number contains at least 6,337,242,000,000 times the number of grains of sand in the whole earth, supposing every cubic inch of the earth to contain 1,000,000 grains. It has been justly remarked by Mr. Ferguson, and other authors, that "if the particles of light were so large that 1,000,000 of them were equal in bulk to an ordinary grain of sand, we durst no more open our eyes to the light than suffer sand to be shot point blank against them from the mouth of a cannon." It may also be remarked, that

[1] See Appendix, Note III.

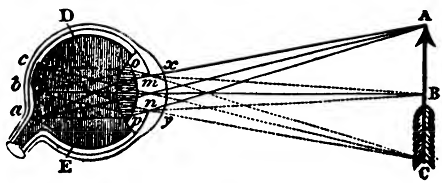
the property of *reflecting* light, which all bodies possess, is essential to the purpose of vision, without which the splendid and variegated scene of nature would be changed into a dreadful gloom; and were the rays of light of one uniform colour, and not compounded of various hues, one object could not be distinguished from another, and the beautiful aspect of our globe would instantly disappear.

Thus we see that the eye is adapted to light, and light to the eye; and in this admirable adaptation the wisdom of the Creator is strikingly displayed. For light has no effect upon the ear, or upon any other organ of sensation, so as to produce a perception of visible objects; as, on the other hand, the undulations of the air have no effect upon the eye, so as to produce the sensation of *sound.* The eye did not produce the light, nor did the light form the eye; they are perfectly distinct from each other, yet so nicely adapted in every particular, that had any one quality or circumstance being awanting in either, the functions of vision could not have been performed in the manner in which they now operate; which strikingly demonstrates, that one and the same intelligent Being, possessed of a wisdom beyond our comprehension, formed the curious structure of the eye, and endued the rays of light with those properties of colour, motion, and minuteness, which are calculated, through the medium of this organ, to produce, in sentient beings, the ideas of visible objects. And surely he never intended that such exquisite skill and contrivance should be altogether overlooked by rational beings, for whose pleasure and enjoyment all this benevolent care is exercised.

Manner in which Vision is Performed.

Let us now attend a little to the manner in which vision is performed, by the medium of light acting on the organs of sight. If we take a common convex glass—a reading-glass, for example—and hold it at some distance from a candle or a window-sash, placing a piece of white paper behind the glass, at the distance of its focus, the image of the candle or sash will be painted on the paper, in an inverted position. This experiment may be performed with a better effect, by darkening a room, and placing the convex glass in a hole cut out of the window-shutter, when the rays of light flowing from the objects without, and passing through the

glass, will form a picture of the objects opposite the window, on the white paper, adorned with the most beautiful colours. In a manner similar to this are the images of external objects depicted on the back part of the inner coat or membrane of the eye. The rays of light, proceeding in all directions from surrounding objects, and falling on the eye, are transmitted through the pupil; and being refracted by the different humours, (particularly by the *crystalline* humour, which acts the part of a convex lens,) they converge to a focus on the *retina*, where the images of visible objects are painted in an inverted position; and by means of the optic nerve these images are conveyed to the mind.



SECTION OF THE EYE.

The above Engraving will perhaps more distinctly illustrate this point. Let *a b c x y* represent the globe of the eye, and A B C an object at a certain distance from it. Now, it is well known that every point of a visible object sends out rays of light in all directions; and therefore a certain portion of the rays which flow from the object, A B C, will fall upon the *cornea*, between *x* and *y*, and passing through the *aqueous* humour, *m n*, and the crystalline humour, *o p*, and the *vitreous* humour, D E, will be converged to a focus on the retina, and paint a distinct picture, *a b c*, of the object A B C, in an inverted position. The rays from the point A of the object, after being refracted by the different humours, will be brought to a point at *a*; those from B will be converged at *b*; and those from C at *c*; and of course the intermediate rays between A B and B C will be formed between *a b* and *b c*, and the object will become visible by means of its image or representation being painted on the retina, in all the colours and proportions which belong to it. If we take a bullock's eye, and cut off the three coats from the back

part, and put a piece of thin white paper over that part, and hold the eye towards the window, or any bright object, we shall see the image of the object depicted upon the paper, and in an inverted position, as stated above.

In order that we may more distinctly perceive the wonders of vision, and the numerous circumstances on which it depends, let us suppose ourselves placed on an eminence which commands a view of a variegated and extensive landscape. Let us suppose ourselves stationed on Arthur's Seat, or on the top of Salisbury Crags, in the vicinity of Edinburgh. Turning our face to the north-west, the city, with its castles, spires, and stately edifices, presents itself to our view. Beyond it, on the north and west, a beautiful country, adorned with villas, plantations, and fertile fields, stretches as far as the eye can reach, till the view is bounded by the castle of Stirling, at the distance of more than thirty miles. On the right hand, we behold the port of Leith, the shipping in the roads, the coast of Fife, the isles of Inchkeith and of May, and the frith of Forth gradually losing itself in the German ocean. If we suppose the length of this landscape to be forty miles, and its breadth twenty-five, it will, of course, comprehend an area of one thousand square miles.

The first circumstance which strikes the mind is *the immense multitude of rays of reflected light* which flow in all directions, from the myriads of objects which compose the surrounding scene. In order to form a rude idea of this infinity of radiations I fix my attention on a single object. I direct my eye to Nelson's monument, on the Calton Hill. From the parapet at the top, a thousand different points send forth a thousand different cones of rays, which, entering my eye, render the different parts of it distinctly visible, besides myriads of rays from the same points, which flow in every other direction through the open spaces of the atmosphere which surround them. How many thousands of millions, then, of different radiations must be issuing forth every moment from the whole mass of the monument! And if one object pours forth such a flood of rays, how immense must be the number of radiations which are issuing from all the objects which compose this extensive landscape! Myriads of rays, from myriads of objects, must be crossing each other in an infinity of directions, so that the mind is confounded at the apparent confusion which seems to exist in this

immensity of radiations; yet every ray passes forward in the crowd, in the most perfect order, and, without being blended or confused with any other ray, produces its specific effect on every eye that is open to receive it. But this is not all; these millions of rays, which flow from the minutest points of the surrounding scene, before they can produce the sensation of vision, and form a picture of the landscape on the retina, must be compressed into a space little more than one eighth of an inch in diameter, before they can enter the pupil of the eye; yet they all pass through this small aperture without the least confusion, and paint the images of their respective objects in exactly the same order in which these objects are arranged.—Another circumstance demands attention. The rays which proceed from the objects before me are not all directed to the spot where I stand, but are diffused throughout every point of the surrounding space, ready to produce the same effect wherever sentient beings are present to receive them. Were the whole inhabitants of Edinburgh placed on the sloping declivity of Arthur's Seat, and along the top of Salisbury Crags, and were millions of other spectators suspended in the surrounding atmosphere, similar sensations would be produced, and a scene similar to that which I now behold would be depicted in every eye. Amidst the infinity of cones of light, crossing each other in an infinity of directions, no confusion would ensue, but every spectator whose eyes were in a sound state would obtain a correct view of the scene before him; and hence it happens that, whenever I shift my position, to the right hand or to the left, other streams of light enter my eye and produce the same effect.

Let me now attend to another circumstance, no less admirable then the preceding, and that is, the *distinct impression* which I have of the shape, colour, and motion of the multiplicity of objects I am now contemplating, and the *small space* within which their images are depicted at the bottom of my eye. Could a painter, after a long series of ingenious efforts, delineate the extensive landscape now before me on a piece of paper not exceeding the size of a silver sixpence, so that every object might be as distinctly seen, in its proper shape and colour, as it now appears when I survey the scene around me, he would be incomparably superior to all the masters of his art that ever went before him. This effect, which far transcends the utmost efforts of human genius, is accom-

plished in a moment, in millions of instances, by the hand of Nature, or, in other words, by "the finger of God." All the objects I am now surveying, comprehending an extent of a 1000 square miles, are accurately delineated in the bottom of my eye, on a space *less than half an inch* in diameter. How delicate, then, must be the strokes of that divine pencil which has formed such a picture! I turn my eyes to the castle of Edinburgh, which appears one of the most conspicuous objects in my field of view. Supposing that portion of it which strikes my eye to be 500 feet long, and 90 in height, I find, by calculation, that it occupies only the 600,000th part of the whole landscape, and consequently fills in my eye no more than the 1,200,000th part of an inch. I next direct my eye towards the frith of Forth, and perceive a steam-boat sailing between Queensferry and Newhaven. I distinctly trace its motion for the space of forty minutes, at the end of which it reaches the chain-pier at Newhaven, having passed over a space of five miles in length, which is but the eighth part of the *lineal* extent of the landscape in that direction; and consequently occupies, in the picture formed on my retina, a lineal space of only one sixteenth of an inch in extent. And, if the boat be reckoned about eighty-eight feet in length, its image is only the 300th part of this extent; and of course fills a space in the eye of only the 4800th part of a *lineal* inch. Yet, my perception of the motion of the vessel could be produced only by a corresponding motion of its image in my eye; that is, by the *gradual* motion of a point one 4800th part of an inch in diameter, over a space one 16th of an inch in length. How inconceivably fine and accurate then must be the impression of those strokes which the rays of light, from visible objects, produce on the retina of the eye! The mind is lost in wonder when it attempts to trace so exquisite and admirable an effect.

I take a reflecting telescope, and through it view some of the distant parts of the landscape. My wonder is still increased when I consider the new directions into which the rays of light are bent —the crossings and recrossings, the refractions and reflections, that take place between the mirrors and the lenses of the instrument, and the successive images that are formed; so that, instead of a scene of confusion, which previous to experience, might have been expected from the numerous additional bendings and intersections of the rays, I now perceive hundreds of objects, with the

most perfect distinctness, which were before invisible. Rays of light from distant and minute objects, which a moment before made no sensible impression on my eye, being collected and variously modified by the telescope, now paint a vivid representation of their objects in their true figures, colours, and positions.

From a consideration of the innumerable modifications of the rays of light, and of the immense variety of effects they produce in every region of the earth—I am led to investigate *what proportion of the solar light falls upon our globe,* in order to produce so diversified a scene of sublimity and beauty. Supposing the sun's rays to be chiefly confined, in their effects, within the limits of the planetary system, since they diverge in every direction, they must fill a cubical space 3,600,000,000 miles in diameter; which consequently will contain about 24,000,000,000,000,000,000,000,000,000 of cubical miles, so that an eye, placed in any point of this vast space, would receive a distinct impression from the solar rays. The solidity of the earth is about 264,000,000,000 cubical miles, and, therefore, it receives only the one 90,000,000,000,000,000th part of the light which fills the sphere of the Solar system. So that the light which cheers all the inhabitants of the world, and unvails such a variety of beautiful and magnificent objects, is nothing more than a *single stream* of celestial radiance out of ninety thousand billions of similar streams, which the great source of light is every moment diffusing throughout surrounding worlds. But the solar rays are not confined within the bounds of the planetary system; their influence extends, in every direction, as far as the nearest stars, filling a cubical space at least 40,000,000,000,000 miles in diameter, and which contains 33,500,000,000,000,000,000,000,000,000,000,000,000,000, or thirty-three thousand five hundred sextillions of cubical miles. And were we to institute comparisons and calculations with respect to the possible variety of effects they might produce throughout this immense region, whole pages might be filled with figures, ciphers, and computations. We might compute how many globes similar to the earth, or any of the larger planets, might be contained within this vast space, allowing several hundreds of cubical miles of empty space around each globe—how many myriads of refractions and reflections the rays of light would suffer, in regard to the peculiar objects connected with every one of these globes—how many eyes of sentient beings might be affec-

ted by the diversities of colour, shape, and motion which would thus be produced—and what a variety of shades of light and colour, and what a diversity of scenery would be produced, according to the distances of the respective globes from the central luminary. After what we have just now stated, however, we may rest satisfied with joining in the pious exclamation of one who had just finished a devout survey of the structure of the human frame; "Marvellous are thy works, and that my soul knoweth right well. How precious are thy thoughts unto me, O God!" (or, as the words might be rendered,) "How precious are thy wonderful contrivances concerning me, O God! how great is the sum of them! If I should count them they are more in number than the sand." In what direction soever I turn mine eyes; whatever portion of thy works I investigate, "*I am still with thee.*"[1] Thine infinity and unsearchable wisdom are impressed on every object, so that I feel myself every moment encompassed by thine immensity, and am irresistibly led to wonder and adore.

I shall now conclude these reflections on vision, with two or three additional remarks. It is worthy of notice, in the first place, that the eye has the power of adapting itself to objects placed at different distances. By means of some delicate pieces of mechanism, not hitherto satisfactorily explained, it can perceive, with distinctness, a large object at the distance of six miles, and the next moment it can adjust itself to the distinct perception of an object at the distance of six inches; so that it acts the part both of a telescope and a miscroscope, and can be *instantaneously* adjusted to perform either as the one instrument or as the other. This necessarily supposes a corresponding alteration in the state of the organ every time we lift our eye from a *near* to look at a *distant* object. Either the *cornea* is somewhat flattened, or the crystalline humour is pushed backwards, or both these changes, in combination with others, may concur in causing the rays from distant objects to unite exactly on the retina, without which distant vision cannot be produced. This contrivance, in whatever kind of mechanism it may consist, is one which art would vainly attempt to imitate. We can see objects that are near us with a microscope; and those that are distant with a telescope; but we should in vain attempt to see distant objects with the former, or those that are only a few

[1] Psalm cxxxix, 14, 17, 18.

inches from us with the latter, without a variety of changes being made in the apertures and positions of the glasses belonging to the respective instruments. In this respect, therefore, as well as in every other, the eye is an optical instrument, incomparably superior to any instrument or imitation that art can produce; and were it not for the peculiar property now described, it would be almost unfit for the purpose of vision, notwithstanding all the other delicate contrivances which enter into its construction. If it were adjusted only for the distinct perception of distant objects, every object within the limits of an ordinary apartment would appear a mass of confusion; and were it adjusted solely for viewing objects within the limits of a few feet or inches, the glories of the heavens, and the beautiful landscape of the earth, would be vailed from our sight as if they were enveloped in a mist.

Another circumstance worthy of attention is the power which the *pupil* of the eye possesses of contracting or enlarging the aperture or hole through which the light is admitted. When the light is too weak, the pupil is enlarged; when it is too strong, it is again contracted. Accordingly we find, that when we enter a darksome apartment, though at first nothing can be accurately distinguished, yet, in the course of a minute or two, when the pupil has had time to dilate, we can perceive most objects with considerable distinctness. And, on the other hand, when we pass from a dark room to an apartment lighted up with a number of lustres, we feel uneasy at the sudden glare till the pupil has contracted itself and excluded a portion of the superfluous rays. Were it not for this property we should, for the most part, either be surrounded with a disagreeable gloom, or oppressed with an excessive splendour. It is for this reason that we are unable to look upon the sun without being dazzled, and are under the necessity of closing the eyelids, or of turning away the head, when a strong light suddenly succeeds to darkness.

Again, it may not be improper to observe, how wisely the Author of nature has fixed the distance at which we ordinarily see near objects most distinctly. This distance is generally from five to eight inches from the eye. But, had the eye been formed for distinct vision, at the distance of only *one* inch, the object would have obstructed the light, and room would have been wanting for the performance of many necessary operations which require the

hand to intervene between the eye and the object. And had the limits of distinct vision for near objects been beyond two or three feet, sufficient light would not have been afforded for the inspection of minute objects, and we could neither have written a letter nor have read a book with the same convenience and ease as we are now enabled to do.

From the preceding descriptions and remarks, it will evidently appear, with what admirable skill the different parts of the organs of vision are constructed, and how nicely they are adapted to the several ends they were intended to subserve. Were any one of these parts deficient, or obstructed in its functions, vision would either be impeded, or rendered painful and distressing, or completely destroyed. If any of the *humours* of the eye were wanting —if they were less transparent—if they were of a different refractive power—or if they were of a greater or lesser convexity than they now are, however minute the alteration might be, vision would inevitably be obstructed, and every object would appear confused and indistinct. If the retina, on which the images of objects are painted, were flat instead of being concave, while objects in the middle of the view appeared distinct, every object towards the sides would appear dim and confused. If the *cornea* were as opake as the sclerotica, to which it is joined, or if the retina were not connected with the optic nerve, no visible object could possibly be perceived. If one of the six muscles of the eye were wanting, or impeded in its functions, we could not turn it to the right; if a second were deficient, we could not turn it to the left; if a third, we could not lift it upwards; if a fourth, we could not move it downwards; and if it were deprived of the other two muscles, it would be apt to roll about in frightful contortions. If the eyes were placed in any other part of the body than the head—if they were much more prominent than they now are—if they were not surrounded by the bony socket in which they are lodged—and if they were not frequently covered by the eyelid—they would be exposed to a thousand accidents from which they are now protected. If they wanted moisture, and if they were not frequently wiped by the eyelids, they would become less transparent, and more liable to be inflamed; and if they were not sheltered by the eyebrows, the sweat and moisture of the forehead would frequently annoy them. Were the *light* which acts upon them devoid of

colour—were it not reflected from objects in every direction—were its motion less swift, or its particles much larger than they now are—in short, were any one circumstance connected with the structure of this organ, and with the modification of the rays of light, materially different from its present arrangement, we should either be subjected to the hourly recurrence of a thousand painful sensations, or be altogether deprived of the entertainments of vision.

The various phenomena of vision have lately engaged the attention of the philosophers of our own and other countries; and many have been the theories to explain the phenomena of *single* vision with a *pair* of eyes. The researches of Professor Wheatsone have done more than any other inquirer to place this phenomenon in a clear light. By means of the now well-known instrument, called the *Stereoscope,* we survey two images—one with each eye—viewed at an angle of reflection which converts them into a *single* solid body: that is, a body conveying to the mind an impresssion of *length, breadth, and thickness.* This instrument has been recently modified by Sir David Brewster, who, by cutting a lense in halves, and placing each half so as to represent an eye, has very cleverly imitated the mechanical conditions of sight. This seeing two objects apparently converted into one—the right hand object with the right eye, and the left hand object with the left eye—is called the theory of Binocular Vision.

How admirable an organ then is the eye, and how nicely adapted to unvail to our view the glories of the universe! Without the application of any skill or laborious efforts on our part, it turns in every direction, transports us to every surrounding object, depicts the nicest shades and colours on its delicate membranes, and

> "Takes in, at once, the landscape of the world
> *At a small inlet, which a grain might close,*
> And half creates the wondrous world we see."—Young.

—How strikingly does it display, in every part of its structure and adaptations, the marks of benevolent design, and of infinite intelligence! However common it is to open our eyes, and to behold, in an instant, the beauties of an extensive landscape, and however little we may be accustomed to admire this wonderful effect—there is not a doctrine in religion, nor a fact recorded in Revelation,

more mysterious and incomprehensible. An excellent French writer has well observed—"The sight of a tree and of the sun, which God shows me, is as real and as immediate a revelation as that which led Moses towards the burning bush. The only difference between both these actions of God on Moses and me is, that the first is out of the common order and economy; whereas the other is occasioned by the sequel and connexion of those laws which God has established for the regulation both of man and nature."

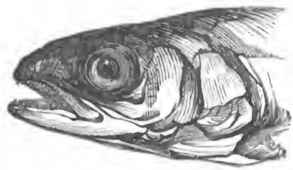
If then the eye of man (who is a depraved inhabitant of a world lying partly in ruins,) is an organ so admirably fitted for extending our prospects of the visible creation, we may reasonably conclude, that organized beings of superior intelligence and moral purity, possess the sense of vision in a much greater degree of perfection than man in his present state of degradation; and that they may be enabled, by their *natural* organs, to penetrate into regions of the universe far beyond what man, by the aid of artificial helps, will ever be able to descry. It may not be altogether extravagant, nor even beyond the reality of existing facts, to suppose that there are intelligences in the regions of Jupiter or Saturn whose visual organs are in so perfect a state that they can descry the mountains of our moon, and the continents, islands, and oceans which diversify our globe, and are able to delineate a map of its surface, to mark the period of its diurnal rotation, and even to distinguish its cities, rivers, and volcanoes. It is quite evident, that it must be equally easy to Divine Wisdom and Omnipotence to form organs with powers of vision far surpassing what I have now supposed, as to form an organ in which the magnificent scene of heaven and earth is depicted, in a moment, within the compass of half an inch. There are animals whose range of vision is circumscribed within the limits of a few feet or inches; and, had we never perceived objects through an organ in the same state of perfection as that with which we are furnished, we could have formed as little conception of the sublimity and extent of our present range of sight, as we can now do of those powers of vision which would enable us to descry the inhabitants of distant worlds. The invention of the telescope shows, that the penetrating power of the eye may be indefinitely increased; and, since the art of man can extend the limits of natural vision, it

is easy to conceive, that, in the hand of Omnipotence, a slight modification of the human eye might enable it, with the utmost distinctness, to penetrate into regions to which the imagination can set no bounds. And therefore it is not unreasonable to believe, that in the future world, this will be one property, among others, of the *resurrection-body*, that it will be furnished with organs of vision far superior to the present, in order to qualify its intelligent inhabitant for taking an ample survey of the "riches and glory" of the empire of God.

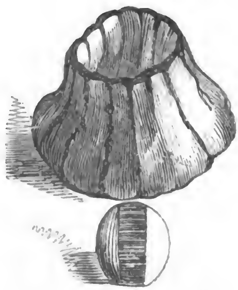
I have dwelt somewhat particularly on the functions of the eye, in order to show, that it is only when we take a *minute* inspection of the operations of the Creator that his infinite wisdom and intelligence are most distinctly perceived. The greater part of Christians will readily admit, that the wisdom of God is manifested in every object; but few of them take the trouble to enquire, *in what particular contrivances and adaptations* this wisdom is displayed; and therefore rest satisfied with vague and general views, which seldom produce any deep impression on the mind. "The works of the Lord," which are "great" and admirable, "*must be sought out* by all those who have pleasure therein; and the more minutely they are inspected, the more exquisite and admirable do all his arrangements appear.

Were we to enter into an investigation of *the visual organs of the lower animals*, and to consider the numerous varieties which occur in their structure, position, and movements, and how nicely the peculiar organization of the eye is adapted to the general structure of the animal, and to its various necessities and modes of existence —the operation of the same inscrutable wisdom and intelligence would meet our eye at every step. *Birds*, for example, which procure their food by their beak, have the power of seeing distinctly at a very small distance; and, as their rapid motion through the air renders it necessary that they should descry objects at a considerable distance, they have two *peculiar* mechanical contrivances, connected with their organs of vision, for producing both these effects. One of these contrivances consists in a flexible rim, formed of bone, which surrounds the broadest part of the eye; and, by occasionally pressing upon its orb, shortens its focal distance, and thus enables it to inspect very near objects. The other consists of a peculiar muscle, which draws back, as occasion requires,

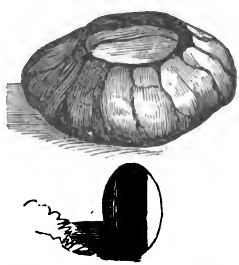
the crystalline humour, by which means it can take a distinct view of a distant landscape, and can pass from the sight of a very near to the sight of a far distant object, with rapidity and ease. In *fishes*, which live in a medium of a different refractive power from that of air, the crystalline humour has a greater degree of convexity, and more nearly approaches to a globular form than that of land animals —which conformation is essentially requisite to distinctness of vision in the watery element. A fish, of course, cannot see distinctly in air, nor a quadruped under water; and every person who has dived into the water with his eyes open knows that, though he may perceive the general forms and colours of objects, his vision is obscure and indistinct. —In *hares* and *rabbits* the eyes are very convex and prominent, so that they can see nearly quite round them; whereas in *dogs*, which pursue these animals, the visual organs are placed more in the front of the head, to look rather before than behind them. Some animals, as *cats* and *owls*, which pursue their prey in the dark, have the pupil of their eye so formed as to be capable of great expansion, so that a few rays of light may make a lively impression on their retina; while the *eagle*, which is able to look directly at the sun, has its pupil capable of being contracted almost to a point.—Insects, such as the *beetle*, the *fly*, and the *butterfly*, whose eyes are incapable of motion, have several thousands of small transparent globes, set in a convex hemisphere, every one



THE HEAD OF A FISH.



Crystalline Lens and Bony Ring of the Eye of the Snowy Owl.

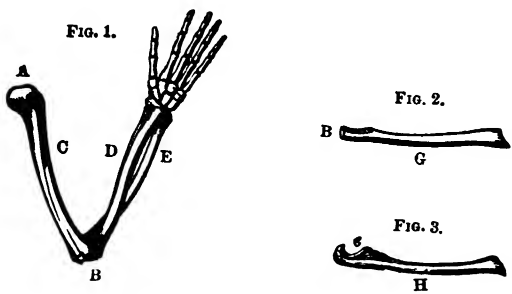


Crystalline Lens and Bony Ring of the Eye of the Golden Eagle.

of which is capable of forming an image of an object; so that they are enabled to view the objects around them without moving their heads. —But it would be beyond the limits of my plan to prosecute this subject any further: enough has already been stated to show that the eyes of men and of other animals are masterpieces of art, which far transcend the human understanding; and that they demonstrate the consummate wisdom of Him who planned and constructed the organical functions of the various tribes of animated existence.

I shall conclude this branch of my subject, by presenting an instance or two of *the mechanism of the bones,* and the movements it is fitted to produce.

The bones of the human frame are *articulated,* or connected together in different ways, but most frequently in the following manner:—Either, first, a bone with a round head is articulated with a cavity, and plays in it as a ball in the socket; or, second, they are connected together by a hinge-like articulation, which enables a bone to move up or down, backwards or forwards, like a



BONES OF THE FORE-ARM.

door upon its hinges. An idea of these two motions, and the purposes they serve, may be obtained, by considering the construction of the pedestal of a telescope, and the joints on which it moves. One of the joints is of the nature of a hinge, by which a vertical motion, or a motion upwards and downwards, is produced. A horizontal motion, or a motion towards the right hand or the left, is produced by a pivot moving in a socket; so that, by these

two motions, the telescope can be made to point in any direction. Such is the nature of the articulations of the bones, and the movements they produce; and whenever one or other of these motions, or both of them combined, is requisite for the comfort and convenience of the individual, such a power of motion is uniformly found to exist. If the movement of a joint in every direction would in any particular case be found inconvenient, the hinge-like articulation is fixed upon: but if a motion in every direction is required for the convenient use of particular members, and for the variety of evolutions which a sentient being may have occasion to make, the ball and socket articulation is combined with the former.

For example, let any person for a moment consider the joints of his fingers, and compare them with the joint at his *wrist*, where the hand is connected with the fore-arm. If he hold the back of his hand upwards, he will find that he can move his fingers upwards or downwards; but he cannot turn them to the right hand or to the left, so as to make them describe a circular motion. He will also find that his *wrist* is capable of a similar movement, so that the hand may be bent in a vertical direction. But, in addition to this motion, it is also capable of being turned in a horizontal direction, or from one side to another. In the former case we have an example of the hinge articulation; in the latter it is combined with an articulation which produces nearly the same effect as a pivot moving in a socket. Now, had the joints of the fingers been capable of the same motions as the wrist, the hand would have lost its firmness, and been incapable of performing a variety of mechanical operations which require objects to be held with a steady grasp. Otherwise, if the wrist had been confined to a vertical motion, the hand would have been incapable of one out of a hundred varied movements it can perform with the greatest ease.[1]

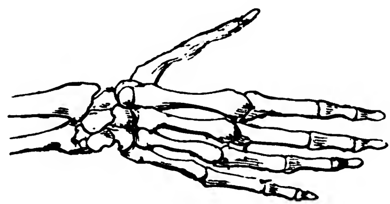
[1] The horizontal motion of the wrist, or that motion by which the palm of the hand is alternately turned up and down, is produced chiefly by the motions of the two bones of the fore-arm, called the *radius* and the *ulna*, one of which is articulated to the *humerus*, or bone connected with the shoulder.—In the engraving, page 128, (fig. 1,) C is the *humerus* or shoulder bone, B is the elbow where the two bones of the fore-arm are connected with the humerus; D is the *radius*, which joins the wrist, on the side where the thumb is, and E the *ulna*, which joins the wrist, on the side where the little finger is. In fig. 2, G is the radius; fig. 3, H *is* the ulna.

In this case, we could not have bored a hole with a gimlet, cut down corn with a sickle, digged the earth with a spade, sewed clothes with a needle, tossed up a ball, or turned up the palm of the hand, for any of the useful purposes for which that motion was ordained.

The *ulna* has a hooked process marked *e* which catches round the lower end of the humerus forming with it a hinge joint. This bone projects beyond the head of the humerus, forming, when the arm is bent, the point of the elbow. The *radius* has a small round head B, on which it turns, without any motion of the humerus—bound to the ulna by ligaments; and as the bones of the wrist are attached to the lower end of this bone alone, and not to the ulna, when the radius revolves the whole hand turns with it. This alternate rolling is what anatomists call *pronation* and *supination*. Flexion and extension of the arm are performed by means of the ulna, which carries the radius along with it in all its movements. While the larger part of the ulna is above, the larger part of the radius is below, so that while the former presents a large surface for articulation at the elbow, the latter does the same at the wrist, and this inverse arrangement likewise contributes to the uniform diameter of the fore-arm. While the fore-arm is thus attached to the humerus, the radius is attached to the wrist, so that when we turn the palm of the hand the radius rolls on the ulna by the help of a groove or hollow near each end of the bone, carrying the hand with it. So admirable indeed is this contrivance, that both motions may be performed at the same time: for while we are bending the arm we may also be rotating or turning it upon its axis. To facilitate these motions, a tubercle of the radius plays into a socket of the ulna, near the elbow—while near the wrist, the radius finds the socket, and the ulna the tubercle.

Now, had both bones been joined to the upper arm at the elbow, or both to the hand at the wrist, the motions now stated could not have been accomplished. The first bone was to be at liberty at one end, and the second at the other, by which means the two motions may be performed together. The bone which carries the fore-arm may swing upon its hinge at the elbow at the very time that the other bone which carries the hand may be turning round it in its grooves. Had there been only a single bone in the fore-arm, with a ball and socket at the elbow, it might, in a certain degree, have accomplished the purpose intended; but in this case, the turning of the hand and arm would have been effected by a comparatively slow and laborious motion. Such is the wonderful care and accuracy with which our all-wise and benevolent Creator has contrived and adjusted every minute part and motion connected with our animal frame to subserve our convenience and pleasure. No one who is acquainted with the minute and exquisite mechanism of the human body will dare to call in question the skill, the design, and the forethought of the great Artificer of that wonderful frame; and he must possess a cold and unfeeling heart who can behold with apathy, and without reverence and gratitude, the multitudinous mass of splendid and exquisite contrivances of which he every moment feels the pleasure and advantage.

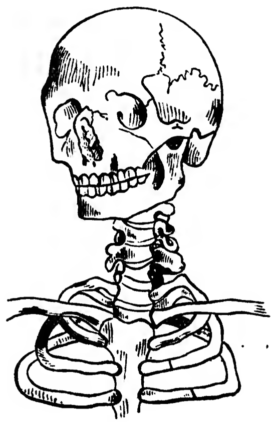
In short, without the rotatory motion of the wrist, the greater part of the operations connected with gardening, agriculture, cookery, washing, spinning, weaving, painting, carving, engraving, building, and other mechanical arts, could not be performed; and such of them as could be effected would be accomplished only with the greatest inconvenience and labour. Any person may convince himself of this by holding his hand in a horizontal position, and preventing his wrist joint from turning round, and then by trying what operations he can easily perform without the rotatory motion; and he will soon perceive with what exquisite skill the numerous movements of our animal frames have been contrived by the great Author of our existence. In each hand there are twenty-seven bones, all of which are essential to the different motions we wish to perform. Every finger is composed of three bones, connected together by articulations, muscles, and ligaments. If, instead of three each finger were composed of only one bone, it would be quite impossible for us to grasp a single object.



BONES OF THE HAND.

In the human hand, in particular, we perceive an instrument far superior to that of any similar part connected with the structure of the lower animals. In this hand we perceive the sensibilities to changes of temperature, to touch, and to motion, combined with a facility in the joints of unfolding and moving in every possible degree and direction, and in a manner inimitable by any artifice of joints and levers. In all the movements of human beings, it is the *hand* that guides them in their industry and mental acquisitions. By its assistance they have drained unwholesome marshes—transformed deserts into fruitful fields—turned the course of rivers—banked out the headlong sea—cleared the thickest forests, and caused cities, temples, and palaces to arise where the wild beasts of the forest formerly roamed at large. In short, by this instrument man has been enabled to prosecute his course along pathless oceans and through the region of the clouds—to measure time and space—to investigate the wonders of the earth and of the heavens, and to promote its progress towards intellectual perfection,—and, without it, scarcely any science or department of human knowledge could be acquired or cultivated—supposing the whole human race to have been destitute of this instrument.

The same admirable contrivance may be perceived in the movements of which the *head* is susceptible. It was requisite, in order to our convenience and comfort, that we should be enabled to move our head backwards or forwards—to look up towards the heavens, or downwards to the ground. It was also expedient that it should have a power of turning to the right or to the left, so as to take in a considerable portion of a circle, without being under the necessity of turning round the whole body. Accordingly we find that both these motions are provided for, in the manner in which the head is connected with the *vertebræ*. The head rests upon the uppermost of these bones, to which it is connected by a hingejoint, similar to those on the fingers, which allows it to move backward and forward; and by means of a round, longish process, or projection, which moves in a socket, it is enabled to move horizontally, as upon an axis. Had the first motion been a wanting, we could not have looked up to the zenith without lying flat on our back; nor could we have looked to the ground without placing our bodies in a prone position; and, in such a case, we could never have seen our own feet unless when they were bent considerably forward. Had the second motion been awanting, we could have looked to nothing except the objects directly before us, without the trouble of turning round the whole body either to the right or to the left. But, in the construction of our corporeal system, every thing is so arranged and adapted to another, as at once to contribute to ease and facility of motion, in all the varied operations and movements we have occasion to perform; which circumstance forcibly demonstrates both the benevolent intentions and the admirable wisdom of Him "whose hands have made and fashioned us," and who "breathed into our nostrils the breath of life."



BONES OF THE HEAD AND NECK.

The above are only two or three out of a hundred of similar instances, which might be produced, to show the benevolent care which has been exercised in arranging and articulating the system of bones of which the propwork of the human frame is composed. Were we to enter into an investigation of the actions and uses of the various muscles, the wonderful system of veins and arteries, the action of the heart, stomach, and bowels; the process of respiration and insensible perspiration, and the system of nerves, glands, lymphatics, and lacteals—a thousand instances of divine wisdom and beneficence would crowd upon our view, which could not fail to excite the pious and contemplative mind to join in the devotions of the "sweet singer of Israel:"—"I will praise thee; for I am fearfully and wonderfully made; marvellous are thy works, and that my soul knoweth right well." But as I intended to present only a few *specimens* of the wisdom of God as displayed in the construction of the material world, I shall conclude this department of my subject with a single reflection.[1]

How foolish and ungrateful is it for rational beings to overlook the wise and benevolent arrangements of the Creator in the material universe! How many thousands of human beings pass their existence without once reflecting on the numerous evidences of divine wisdom and beneficence which appear around them, or feeling the least spark of gratitude for their preservation and comforts, to that Being "in whose hand their breath is, and whose are all their ways"! Yea, how many are there who consider themselves as standing high in the ranks of the Christian profession who affect to look down with a certain degree of contempt on the study of the material works of God, as if it were too gross a subject for their spiritual attainments! They profess to trace the wisdom of God in the Scriptures, and to feel gratitude for his pardoning mercy, but they seldom feel that gratitude which they ought to do for

[1] Those who wish to prosecute this subject, particularly that part of it which relates to the contrivances of divine wisdom which appear in the animal system, will find ample gratification in Nieuwentyt's 'Religious Philosopher,' vol. 1, Bell's Bridgewater Treatise on 'The Hand,' and Dr. Paley's Natural Theology. A variety of useful remarks on this subject will also be found in 'Ray's Wisdom of God in the Creation,' Derham's 'Physico-Theology,' and Bonnet's 'Contemplation of Nature.'

those admirable arrangements in their own bodies, and in the elements around them, by which their lives are preserved and their happiness promoted; and even seen to insinuate that they have little or nothing to do with the contrivances of the God of nature. They leave it to the genius of the infidel philosophers to trace the articulation of the bones, the branchings of the veins and arteries, the properties of light and the composition of the atmosphere, while they profess to feast their minds on more sublime and spiritual entertainments. But surely such astonishing displays of the wisdom and benignity of the Most High as creation exhibits were never intended to be treated by his intelligent offspring with apathy or indifference; and to do so must indicate a certain degree of base ingratitude towards Him whose incessant energy sustains the whole assemblage of sentient and intelligent beings, and who displays himself, in their construction and preservation, to be "wonderful in counsel and excellent in working." Shall we imagine, that because God stands in the gracious relation of our Redeemer, he has ceased to stand in the relation of our Creator and preserver? Or shall we consider those subjects as unworthy of our attention, which are the theme of the praises of the heavenly host?[1] Can we suppose that the Almighty displayed his infinite wisdom in the curious organization of the human eye, that man—the only being in this world who is endued with faculties capable of appreciating its structure, and for whose use and entertainment it was intended—should overlook such a wonderful piece of divine workmanship, and feel no gratitude for the bestowment of so admirable a gift? Shall we extol the ingenuity displayed in a clock or a watch, in a chess-player or a steam-engine, and shall we feel no sentiment of admiration at the view of millions of instances of divine mechanism, which infinitely transcend the powers of the human understanding? To act in this manner, as too many are disposed to do, is unworthy of man, both as a Christian and as an intelligent agent. Such was not the conduct of the inspired writers; their spirituality of views did not lead them to neglect the contemplation of *any* of the works of God. "I will meditate on *all* thy works," says the Psalmist, "and talk of all thy doings; I will utter abundantly the memory of thy great goodness, and speak of all thy wondrous works." Accordingly we find that the wonders of the human frame, the economy of the animal and the vegetable tribes, the

[1] Revelation, iv, 11.

scenery of the "dry land," and of the "mighty deep," and the glories of the heavens, were the frequent subjects of their devout contemplation. They considered them in relation to the unceasing agency of God, by whom they were formed and arranged, and as declaring his wisdom, goodness, and omnipotence; and with this view ought all the scenes of the visible creation to be investigated by his intelligent creatures.

We have reason to believe that it is owing, in part, to want of attention to the divine wisdom and beneficence, as exhibited in the construction of the visible world, that many professed Christians entertain so vague and confused ideas respecting the wisdom and goodness of Deity, as displayed in the economy of redemption. The terms wisdom, goodness, and beneficence, in their mouths, become words almost without meaning, to which no precise or definite ideas are attached; because they have never considered the instances and the evidences of these attributes as displayed in the material creation. And if our minds have not been impressed with a sense of the wisdom and beneficence of God in those objects which are presented to the external senses, we cannot be supposed to have luminous and distinct ideas of those spiritual objects and arrangements which are removed beyond the sphere of our corporeal organs. For all our ideas in relation to religion and its objects are primarily derived from the intimations we receive of external objects through the medium of our senses; and, consequently, the more clearly we perceive the agency of God in his visible operations, the more shall we be qualified to perceive the wisdom and harmony of his dispensations as recorded in the volume of inspiration.

We live in a world all the arrangements of which are the effects of infinite wisdom. We are surrounded with wonders on every hand; and therefore we cease to admire or to fix our attention on any one of the wonders daily performed by God. We have never been accustomed to contemplate or to inhabit a world where benevolence and wisdom are not displayed; and therefore we are apt to imagine that the circumstances of our terrestrial existence could not have been much otherwise than they actually are. We behold the sun in the morning ascending from the east—a thousand shining globes are seen in the canopy of the sky when he has disappeared in the west. We open our eyelids, and the myriads of

objects which compose an extensive landscape are in a moment painted on our retina; we wish to move our bodies, and in an instant the joints and muscles of our hands and feet perform their several functions. We spread out our wet clothes to dry, and in a few hours the moisture is evaporated. We behold the fields drenched with rain, and in a few days it disappears and is dispersed through the surrounding atmosphere, to be again embodied into clouds. These are all *common* operations, and therefore thoughtless and ungrateful man seldom considers the obligations he is under to the Author of his existence, for the numerous enjoyments which flow from these wise arrangements. But were the globe we inhabit and all its appendages to remain in their present state—and were only the principle of *evaporation* and the *refractive* and *reflective properties of the air* to be destroyed—we should soon feel, by the universal gloom which would ensue, and by a thousand other inconveniences we should suffer, what a miserable world was alloted for our abode. We should most sensibly perceive the wisdom and goodness we had formerly overlooked, and would most ardently implore the restoration of those arrangements for which we were never sufficiently grateful. And why should we not *now*—while we enjoy so many conforts flowing from the plans of infinite wisdom—have our attention directed to the benevolent contrivances within us and around us, in order that grateful emotions may be hourly arising in our hearts to the Father of our spirits? For the essence of true religion consists chiefly in *gratitude* to the God of our life and the Author of our salvation; and every pleasing sensation we feel from the harmonies and the beauties of nature ought to inspire us with this sacred emotion. "Hearken unto this, O man! stand still and consider the wonderful works of God. Contemplate the balancings of the clouds, the wondrous works of Him who is perfect in knowledge." He hath made the earth by his power, he hath established the world by his wisdom. When he uttereth his voice there is a noise of waters in the heavens; he causeth the vapours to ascend from the ends of the earth, and bringeth the winds out of his treasuries." While it is shameful for man to be inattentive to the wonders which surround him, what can be more pleasing and congenial to a rational and devout mind than contemplations on the works of the Most High? "What can be more gratifying," says Sturm, "than to contemplate in the

heavens, in the earth, in the water, in the night and day, and indeed throughout all nature, the proofs which they afford of the wisdom and purity and the goodness of our great Creator and preserver! What can be more delightful than to recognize, in the whole creation, in all the natural world, in every thing we see, traces of the ever-working providence and tender mercy of the great Father of all."

SECTION IV.

ON THE GOODNESS OR BENEVOLENCE OF THE DEITY.

The benevolence of God is that perfection of his nature by which he communicates happiness to the various ranks of sensitive and intelligent existence.

The system of nature, in all its parts, exhibits an unbounded display of this attribute of the Divine mind, both in relation to man, and in relation to the subordinate tribes of animated existence. In relation to *Man*—the magnificence and glory of the heavens—the variegated colouring which is spread over the scene of nature—the beautiful flowers, shrubs, and trees, with which the earth is adorned, which not only delight the eye, but perfume the air with their delicious odours—the various kinds of agreeable sounds that charm the ear—the music of the feathered songsters, which fill the groves with their melody—the thousands of pleasant images which delight the eye, in the natural embellishments of creation—the agreeable feelings produced by the contact of almost every thing we have occasion to touch— the pleasure attached to eating, drinking, muscular motion, and activity—the luxuriant profusion and rich variety of aliments which the earth affords—and the interchanges of thought and affection—all proclaim the benevolence of our almighty Maker, and show, that the communication of happiness is one grand object of all his arrangements. For these circumstances are not *essentially* requisite to our existence. We might have lived and breathed and walked though every thing we touched had produced pain; though every thing we ate and drank had been bitter; though every movement of our hands and feet had been accompanied with uneasiness and fatigue; though every sound had been as harsh as the saw of the carpenter; though

no birds had warbled in the groves; though no flowers had decked the fields, or filled the air with their perfumes; though one unvaried scene of dull uniformity had prevailed, and beauty and sublimity had been swept from the face of nature; though the earth had been covered with a mantle of black, and no radiant orbs had appeared in our nocturnal sky. But what a miserable world should we then have inhabited, compared with that which we now possess! Life would have past away without enjoyment, and pain would have overbalanced the pleasures of existence. Whereas, in the existing constitution of things, all the objects around us, and every sense of which we are possessed, when preserved in its natural vigour, have a direct tendency to produce pleasing sensations, and to contribute to our enjoyment: and it is chiefly when we indulge in foolish and depraved passions, and commit immoral actions, that the benevolent intentions of the Deity are frustrated, and pain and misery produced.

Had the Creator of the world been a malevolent being, and possessed of infinite power and intelligence, every arrangement of nature would have been almost the reverse of what we now find it. The production of *evil*, and of pain in sensitive beings, would have been the *aim* of the contriver in all his operations and allotments. All design in the frame of the universe, and all that wisdom and intelligence which we now admire in the adaptations of the parts and functions of animals to their necessities and to the constitution of nature around them—we should have dreaded as contrivances to produce painful sensations, and to render them acute and permanent. Instead of ease and enjoyment and delight in the exercise of our functions and faculties, the ordinary state of the lower animals and of human beings would have been a state of trouble, disease, dejection, and anguish. Every breath of air might have cut us like the point of a dagger, or produced a pain like that of swallowing aquafortis or sulphuric acid.[1] Every touch might have been felt like the sting of a nettle, or like the rubbing of salt upon a festering wound. Every taste would have been bitter as gall and wormwood, and every sound harsh and

1 Sulphuric acid consists of 75 parts *oxygen*, and 25 parts *nitrogen*, which form the constituent parts of the air we breathe, only in a different proportion. Were this proportion materially altered, we should feel the most excruciating pain in attempting to breathe it in some of its combinations.

dissonant, or as a hideous scream. All our senses, instead of being the sources of pleasure, as they now are, would have been the instruments of pain and torture. The lower animals, instead of ministering to our delight and necessities, would have been formed so as to torment, to harass, and annoy us. The cow and the goat would have afforded us no milk, nor the bee its honey, nor would the birds of the air have charmed us with their music. Dismal and haggard objects would have been strewed over the whole face of creation, and all would have appeared a melancholy gloom, without beauty or variety. The fields would have wanted their delightful verdure, their diversified aspect, and the beautiful flowers with which they are now adorned. The fire might have scorched without warming us, and water, instead of refreshing us, might have produced intolerable pain. The light might have been without colour; it might have dazzled instead of cheering us, and prevented distant objects from being perceived. Our eye-balls might have wanted the muscles which now enable them to move with ease in every direction, and every ray of light might have affected them with pain. The ground might have been formed so soft and yielding that at every step we should have sunk like persons walking in a quagmire.—In short, our imaginations, in such a case, would have presented to us little else than frightful spectres and objects of terror and alarm,—and our minds have been filled with dismal forebodings and dreadful expectations. But, every arrangement in the system of nature, as it is now constituted, is directly the reverse of what we have now supposed. And this consideration demonstrates, that the great creator of the universe is the God of love, whose mercy and benevolence are displayed toward every rank of sensitive and intelligent existence, and these attributes, we are assured, will never cease in their operations, so long as the universe endures.

If we consider, further, that the inexhaustible bounty of the Creator, and the numerous pleasures we enjoy, are bestowed upon a guilty race of men, the benevolence of the Deity will appear in a still more striking point of view. Man has dared to rebel against his Maker; he is a depraved and ungrateful creature. The great majority of our race have banished God from their thoughts, trampled upon his laws, neglected to contemplate his works, refused to pay him that tribute of reverence and adoration which his perfec-

tions demand, have been ungrateful for his favours, have blasphemed his name, and have transferred to "four-footed beasts and creeping things," that homage which is due to him alone. It has been the chief part of their employment, in all ages, to counteract the effects of his Beneficence, by inflicting injustice, oppression, and torture upon each other; by maiming the human frame, burning cities and villages, turning fruitful fields into a wilderness, and, by every other act of violence, carrying death and destruction through the world. And if *water, air,* and the *light of heaven,* had been placed within the limits of their control, it is more than probable, that whole nations would have been occasionally deprived of these elements, so essential to human existence. Yet, notwithstanding the prevalence of such depraved dispositions, the streams of Divine benevolence towards our apostate race have never yet been interrupted. The earth has never stopped in its career, and thrown nature into a scene of confusion; the light of heaven has never ceased to illumine the world; the springs of water have never been dried up, nor has the fertile soil ceased to enrich the plains with golden harvests. God "hath not left himself without a witness" to his beneficence, in any age, in that he hath unceasingly bestowed on the inhabitants of the world, "rain from heaven and fruitful seasons, filling their hearts with food and gladness." This is one of the characters of Deity which forms the most perfect contrast to the selfish and revengeful dispositions of man, which as far transcends human benevolence as the heavens in extent surpass the earth—a character calculated to excite our highest love and admiration, and which we are called upon, in the sacred oracles, to imitate and revere: "Be ye merciful, as your Father who is in heaven is merciful; for he maketh his sun to rise on the evil and on the good, and sendeth rain on the just and on the unjust." "O that men would praise the Lord for his goodness, and for his wonderful works to the children of men!"

From such considerations we learn, even from the system of nature, that *mercy* is an attribute of the Deity; for if mercy consists in bestowing favours on those who are unworthy, or who merit punishment, the greatest sinners in all ages have shared in it, and every individual of the human race, now existing, enjoys a certain portion of those comforts which flow from the benevolent arrangements which the Creator has established: "He maketh the sun

to arise *on the evil* and on the good." Though the nations in ancient times, as well as at present, "walked in their own ways," indulging in impiety, falsehood, lewdness, war, devastations, revenge, abominable idolatries, and every other violation of his law, he still supported the functions of their animal frames, and caused the influences of the sun, the rains, and the dews, to descend upon their fields, that they might be refreshed with his bounty, and filled "with food and gladness." If mercy were not an essential attribute of the Deity, he would have cut them down in the midst of their first transgressions, shattered to pieces the globe on which they dwelt, and buried them in eternal oblivion. But whether Divine mercy will extend to the final forgiveness of sin, and the communication of eternal happiness to such beings, can be learned only from the discoveries of revelation.

In relation to the *inferior animals*—the immense multitude of living creatures with which the earth is replenished is a striking evidence of the vast profusion of the beneficence of the Almighty. More than 100,000 species of animated beings are dispersed through the different regions of the air, the water, and the earth, besides myriads which are invisible to the unassisted eye. To estimate the number of individuals belonging to any one species is beyond the power of man. What countless myriads of herrings, for example, are contained in a single shoal, which is frequently more than six miles long, and three miles broad! To estimate the number of individuals in all the different species, would therefore be as impossible as to count the grains of sand in the Arabian deserts. There is not a single spot in any region of the globe but what teems with animated beings. Yet all this vast assemblage of sensitive existence is amply provided for by the bountiful Creator. "These all wait upon him, and he giveth them their meat in due season." They enjoy not only life, but also a *happy* existence. The sportive motions and gesticulations of all the animal tribes—the birds skimming through the air, warbling in the groves, and perching on the trees—the beasts of the field bounding in the forests and through the lawns—the fishes sporting in the waters—the reptiles wriggling in the dust—and the winged insects, by a thousand wanton mazes—all declare that they are rejoicing in their existence, and in the exercise of those powers with which the Creator has furnished them. So that wherever we turn our eyes, we

evidently perceive that the "earth is full of the goodness of the Lord," and that "his tender mercies are over all his works."

This subject is boundless; but it would be inconsistent with the limited plan of this work to enter into any particular details. And it is the less necessary, when we consider that every instance of divine wisdom is at the same time an instance of *benevolence;* for it is the ultimate object of all the wise contrivances in the system of nature, that happiness may be communicated to the various ranks of sensitive and intelligent existence. *Goodness* chooses the *end*, and *wisdom* selects the most proper *means* for its accomplishment; so that these two attributes must always be considered in simultaneous operation. And therefore, the instances I have already specified of the wisdom and intelligence of the Creator may also be considered as exemplifications of divine benevolence. I shall therefore conclude this topic with the following extract from Dr. Paley:—

"Contrivance proves design; and the prominent tendency of the contrivance indicates the disposition of the designer. The world abounds with contrivances; and all the contrivances we are acquainted with are directed to beneficial purposes. Evil, no doubt exists; but it is never, that we can perceive, the object of contrivance. Teeth are contrived to eat, not to ache; their aching now and then is incidental to the contrivance, perhaps inseparable from it; or even, if you will, let it be called a defect in the contrivance, but it is not the *object* of it. This is a distinction that well deserves to be attended to. In describing implements of husbandry, you would hardly say of a sickle, that it is made to cut the reaper's fingers, though from the construction of the instrument, and the manner of using it, this mischief often happens. But if you had occasion to describe instruments of torture or execution,—this, you would say, is to extend the sinews; this to dislocate the joints; this to break the bones; this to scorch the soles of the feet. Here pain and misery are the very *objects* of the contrivance. Now, nothing of this sort is to be found in the works of nature. We never discover a train of contrivance to bring about an evil purpose. No anatomist ever discovered a system of organization calculated to produce pain and disease; or, in explaining the parts of the human body, ever said, this is to irritate; this to inflame; this duct is to convey the gravel to the kidneys; this gland to

secrete the humour which forms the gout. If, by chance he come to a part of which he knows not the use, the most he can say is, that it is useless; no one ever suspects that it is put there to incommode, to annoy, or torment. Since, then, God hath called forth his consummate wisdom to contrive and provide for our happiness, and the world appears to have been constituted with this design at first, so long as this constitution is upheld by him, we must, in reason, suppose the same design to continue."[1]

Thus I have endeavoured, in this and the preceding section, to exhibit a few specimens of the wisdom and goodness of God in the system of nature. These might have been multiplied to an indefinite extent; but the instances adduced, I presume, are sufficient to show, that the economy of the material world is not altogether a barren subject to a pious and contemplative mind. Every intelligent believer in Revelation will readily admit, that it would be a highly desirable object, to induce upon the mass of Christians such a habit of devout attention to the visible works of creation as would lead them, in their social and solitary walks, to recognize the agency of God in every object they behold; to raise their thoughts to him as the great first Cause, and to expand their hearts with emotions of gratitude. How very different must be the sentiments and the piety of the man who looks on the scene of wisdom and magnificence around him with a "brute unconscious gaze," as thousands of proffessed Christians do—and the grateful and pious emotions of him who recognizes the benevolent agency of God in the motions of his fingers and his eye balls; in the pulsation of his heart; in the picture of external objects every moment formed on his retina; in the reflection of the rays of light, and the diversified colours they produce; in the drying of his clothes; in the constitution of the atmosphere; in the beauty and magnificence of the earth and the heavens; and in every other object that meets his eye in the expanse of nature! The numberless astonishing instances of Divine agency, which every where present themselves to our view in the scene around us, seem evidently intended to arrest the mind to a consideration of an "ever-present Deity;" and I envy not the sentiments or the feelings of that man who imagines that he stands in no need of such sensible mediums, to impress his mind with a sense of the benevolent care and *omnipresence* of God.

1 Paley's Moral Philosophy, Book II., Chap. v.

CHAPTER II.

CONTAINING A CURSORY VIEW OF SOME OF THE SCIENCES WHICH ARE RELATED TO RELIGION AND CHRISTIAN THEOLOGY.

THEOLOGY has generally been viewed as a study of a very limited range: and hence, when it has been admitted into the circle of the sciences, a much smaller space has been alloted for its discussion than has been devoted to almost any other department of human knowledge. When considered, however, in its most extensive sense—in its relations to the divine Being—to his past and present dispensations towards the human race—to the present circumstances and the future destiny of man—and to the physical and moral condition of all the sentient and intelligent beings of which we have any intimation—it ought to be viewed as the most varied and comprehensive of all the sciences; as embracing, within its extensive grasp, all the other departments of useful knowledge both human and divine. As it has God for its object, it must include a knowledge of the universe he has formed—of the movements which are continually going on throughout the wide extent of his empire, in so far as they lie open to our inspection—of the attributes which appear to be displayed in all his operations—of the moral laws he has framed for the regulation of holy intelligencies—of the merciful arrangements he has made for the restoration of fallen man—of the plans by which the knowledge of his will is to be circulated and extended in the world in which we live—of the means by which truth, and moral purity, and order, are to be promoted among our apostate race, in order to their restoration to the happiness they have lost—together with all those diversified ramifications of knowledge, which have either a more remote or a more immediate bearing on the grand objects now specified. Like the lines which proceed from the circumference to the centre of an immense circle—all the *moral*[1] arts and sciences which have been invented by men—every department of human knowledge, however far it may, at first sight, appear to be removed from religion—may

[1] The epithet *moral* is here used in its application to arts, because there are certain arts which must be considered as having an *immoral* tendency, such as, the art of war, the art of boxing, of gambling, etc., and which, therefore, cannot have a direct tendency to promote the objects of religion.

be considered as having a direct bearing on Theology, as the grand central point, and as having a certain tendency to promote its important objects.

It is much to be regretted, that Theology has so seldom been contemplated in this point of view—and that the sciences have been considered rather as so many independent branches of secular knowledge than as subservient to the elucidation of the facts and doctrines of religion, and to the accomplishment of its benevolent designs. Hence it has happened that philosophy and religion, instead of marching hand in hand to the portals of immortality, have frequently set themselves in hostile array; and combats have ensued equally injurious to the interests of both parties. The philosopher has occasionally been disposed to investigate the economy of nature, without a reference to the attributes of that almighty Being who presides over its movements, as if the universe were a self-moving and independent machine; and has, not unfrequently, taken occasion, from certain obscure and insulated facts, to throw out insinuations hostile to the truth and the character of the Christian revelation. The theologian on the other hand, in the heat of his intemperate zeal against the infidel philosopher, has unguardedly been led to declaim against the study of science, as if it were unfriendly to religion—has, in effect, set the works of God in opposition to his word—has confounded the foolish theories of speculative minds with the rational study of the works of Deity—and has thus prevented the mass of mankind from expanding their minds by the contemplation of the beauties and sublimities of nature.

It is now high time that a complete reconciliation were effected between these contending parties. Religion ought never to disdain to derive her supports and illustrations from the researches of science; for the investigation of philosophy into the economy of nature, from whatever motives they may be undertaken, are nothing else than an enquiry into the plans and operations of the Eternal Mind. And philosophy ought always to consider it as her highest honour to walk as a handmaid in the train of that religion which points out the path to the religion of eternal bliss. By their mutual aid, and the subserviency of the one to the other, the moral and intellectual improvement of man will be promoted, and the benevolent purposes of God in the kingdom of providence gradually accomplished. But, when set in opposition to each other, the human mind is bewildered and retarded in its progress, and the Deity is apt to be considered as set in opposition to himself—as proclaiming one

system of doctrines from the economy of revelation, and another, and an opposite system, from the economy of nature. But if the Christian revelation, and the system of the material world, derived their origin from the same almighty Being, the most complete harmony must subsist between the revelations they respectively unfold; and the apparent inconsistencies which occur must be owing chiefly to the circumstances of our present station in the universe, and to the obscure and limited views we are obliged to take of some of the grand and diversified objects they embrace. And therefore we have reason to believe, that when the system of nature shall be more extensively explored, and the leading objects of revelation contemplated in a clearer light, without being tinged with the false colouring of party opinions and contracted views, and when rational enquirers shall conduct their researches with a greater degree of reverence, humility, and Christian temper—the beauty and harmony of all the plans and revelations of the Deity, in reference both to the physical and the moral world, will be more distinctly perceived and appreciated.

In the following cursory sketches, it forms no part of my plan to trace even an *outline* of the different sciences which are connected with religion, much less to enter into any particular details in relation to their facts and principles. It would be comparatively easy to fill up the remaining sheets of this volume with skeletons of the different sciences; but such meagre details as behoved to be brought forward, could not be interesting to the general reader, and would fail in accomplishing the objects proposed. My design simply is, to select some leading facts, or general truths, in relation to some of the physical sciences, for the purpose of showing their connection with the objects of religion, and the interests of rational piety. At the same time, such definite descriptions will be given as will enable common readers to appreciate the objects and bearings of the different branches of knowledge which may be presented to their view.

The first science[1] I shall notice, is that of

1 The term *science*, in its most general and extensive sense, signifies *knowledge*, particularly that species of knowledge which is acquired by the exertion of the human faculties. In a more restricted sense, it denotes a *systematic* species of knowledge which consists of rule and order, such as Mathematics, Astronomy, Natural Philosophy, etc.—In the discussions contained in this work, it is used in its most general sense, as denoting the various departments of human knowledge; in which sense, history, both natural, civil, and sacred, may be termed *science*.

Natural History.

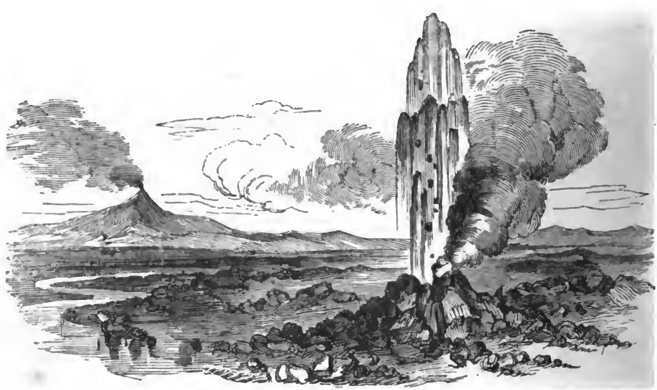
This science, taken in its most comprehensive sense, includes a knowledge and description of all the known facts in the material universe.

It is to be regretted, that most books published under the title of *Natural History* to which common readers have access contain nothing more than a general description of animals, as if this science were confined merely to one class of beings; whereas there is an infinite variety of other objects, seldom noticed, which would appear no less interesting, and, in some instances, much more novel and gratifying to the general reader and to the youthful mind. All the diversified forms of matter, whether existing on the surface or in the bowels of the earth, in the ocean, the atmosphere, or in the heavens, from the legitimate objects of this department of the science of nature.

TROPICAL VEGETATION.

Were we, therefore, to sketch a comprehensive outline of the subjects of Natural History we might, in the first place, take a cursory survey of the globe we inhabit, in reference to its magnitude, figure, motions, and general arrangements—the form, relations, and extent of its continents—the numerous islands which

diversify the surface of the ocean—the magnitude, the direction, and the extent of its rivers, and the quantity of water they pour into the ocean—the direction, elevation, and extent of the different ranges of mountains which rise from its surface—the plains, morasses, lakes, forests, dells, and sandy deserts, which diversify its aspect—the extent, the motions, the colour, and the different aspects of the ocean, and the facts which have been ascertained respecting its saltness, its depth, its bottom, and its different currents. We might next take a more particular view of some of the most remarkable objects on its surface, and give a detail of the facts which are known respecting the history of *volcanoes*—their number—the countries in which they are situated—the awful phenomena they exhibit—and the devastations they have produced—the history of *earthquakes*, their phenomena and effects, and the countries most subject to their ravages—basaltic and rocky wonders, natural bridges, precipices, cataracts, ice islands, icebergs, glaciers, whirlpools, mineral wells, reciprocating fountains, boiling



GEYSER OR BOILING SPRING, ICELAND.

springs, sulphuric mountains, bituminous lakes, volcanic islands—the various aspects of nature in the different zones, and the contrasts presented between the verdant scenes of tropical climes. and the icy cliffs of the polar regions. We would next take a survey of the subterraneous wonders which lie beneath the surface of the earth—the immense chasms and caverns which wind in various directions among the interior strata of our globe—such as the great

Kentucky cavern, and the grotto of Antiparos—the mines of salt, coal, copper, lead, diamond, iron, quicksilver, tin, gold, and silver—the substances which compose the various strata, the fossil bones, shells, and petrifactions which are imbedded in the different layers, and the bendings and disruptions which appear to have taken place in the substances which compose the exterior crust of the earth. We might next survey the *atmosphere* with which the earth is environed, and give a detail of the facts which have been ascertained respecting its specific gravity and pressure, the elementary principles with which it is compounded, its refractive and reflective powers, and the phenomena which result from its various properties and modifications—the *meteors* which appear in its different regions—thunder and lightning, winds, hail, rain, clouds, rainbows, parhelias or mock-suns, meteoric stones, the aurora

FATA MORGANA, NAPLES.

borealis, luminous arches, ignes fatui, the mirage, the fata morgana, hurricanes, monsoons, whirlwinds and waterspouts, sounds and echoes.

In prosecuting our survey of sublunary nature, we would next advert to the various orders of the *vegetable tribes*—their anatomical structure—the circulation of their juices—the food by which they are nourished—the influence of light and air on their growth and motions—their male and female organs—their periods of longevity—their modes of propagation—their diseases and dissolution—their orders, genera, and species—their immense variety—

their influence on the salubrity of the atmosphere—the relation which their trunks, roots, leaves, and fruits bear to the wants of man and other animals, in supplying food, clothing, and materials for constructing habitations—the gums and resinous substances they exude—the odours they exhale—the variety of colours they exhibit—the vast diversity of forms in which they appear—and the beauty and variety which they spread over the whole face of nature.

The *mineral kingdom* would next require to be surveyed. We would enquire into the facts which have been ascertained respecting the *earthy, saline, inflammable,* and *metallic* substances, which are found on the surface and in the bowels of the earth—there specific and distinguishing characters—the elementary principles, or simple substances, of which they are composed—the regions of the earth where the respective minerals most frequently abound—and the ends which they are designed to accomplish in the constitution of the globe. We would consider, more particularly, the various metals, such as iron, copper, lead, tin, gold, silver, bismuth, zinc, etc. in reference to the substances with which they are united in their native ores—the changes produced upon them by the action of oxygen and the different acids—their combustibility—their combination with phosphorus, sulphur, and carbon—the various compounds into which they may be formed—their important uses in the arts which minister to the comfort and embellishment of human life—their relation to the multifarious necessities of man—and the wisdom and goodness of the Creator, as displayed in their arrangement in the bowels of the earth, and in the admirable properties of which they are possessed. In these details, the natural history of *Iron* would hold a prominent place. In point of *utility,* it claims the highest rank in the class of metals, and is intrinsiclly more valuable than gold and silver, and all the diamonds of the East. There is scarcely a mineral substance in the whole compass of nature which affords a more striking instance of the beneficial and harmonious adaptation of things in the universal system. We would, therefore, consider it in reference to its vast abundance in all parts of the world—the numerous substances into which it enters into combination—its magnetical property—its capability of being fused and welded—the numerous useful utensils it has been the means of producing—its agency in carrying forward improvements in art and science, in the civilization of barbarous tribes, and in promoting the progress of the human mind; and the aids which it affords to the Christian missionary in heathen lands.

Having surveyed the inanimate parts of the terraqueous globe, and its appendages, we might next direct our attention to the animated tribes with which it is peopled. Beginning at *Man*, the head of the animal creation, we would detail the principal facts which have been ascertained respecting his structure and organical functions—the muscular movements of the human body, the system of bones, nerves, veins, and arteries; the process of respiration; and the organs of vision, hearing, smelling, tasting, and feeling, by which he holds a correspondence with the material world—the modifications which appear in his corporeal frame, and in his mental faculties, during the periods of infancy, puberty, manhood, and old age—the causes and phenomena of sleep and dreaming—the varieties of the human race, in respect of colour, stature, and features—the deviations from the ordinary course of nature, which occasionally occur, in the case of monsters, dwarfs, and giants—the moral and intellectual faculties—and those distinguishing characteristics which prove the superiority of man over the other tribes of animated nature.

The inferior ranks of the animal creation would next demand our attention. We would take a survey of the numerous tribes of *quadrupeds, birds, fishes, serpents, lizards,* and *insects,* in reference to the characteristic marks by which the different species are distinguished; their food and habitations; the different modes in which they display their architective faculty, in constructing places of abode for shelter and protection; the clothing with which they are furnished; their sagacity in finding out the proper means for subsistence and self-preservation; their hostilities; their artifices in catching their prey and escaping their enemies; their modes of propagation; their transformations from one state and form to another; their migrations to different countries and climates; their various instincts; their care in rearing and protecting their young, their passions, mental characters, and social dispositions; their language or modes of communication with each other; their capacities for instruction and improvement; their different powers of locomotion; the adaptation of all their organs to the purposes for which they seen intended; the indications they give of being possessed of moral dispositions and rational powers; their different periods of longevity, and the ends which they are intended to subserve in the system of nature. Along with these details, certain views might be exhibited of the various forms of sensitive life and modes of existence which obtain in those numerous species of

animals which are invisible to the naked eye, and which the microscope discovers in almost every department of nature.

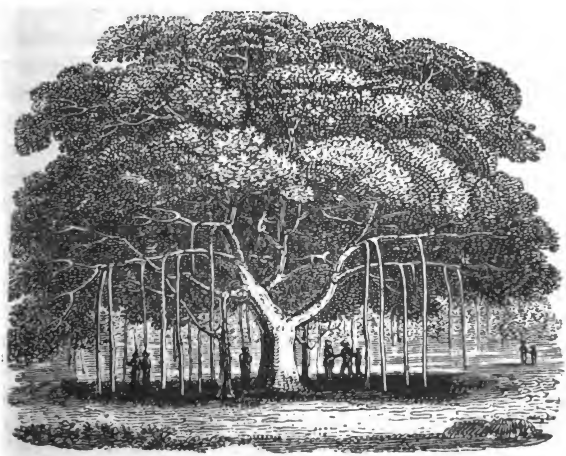
Having surveyed the objects which compose our sublunary system, we would next direct our view to the regions of the sky, and contemplate the facts which have been discovered in relation to the celestial orbs. We would first attend to the *apparent* motion of the sun, the different points of the horizon at which it seems to rise and set, and the different degrees of elevation to which it arrives, at different seasons of the year; the different aspects it presents as viewed from different parts of the earth's surface, and the different lengths of days and nights in different parts of the world. We would next attend to the varied phases of the moon; the direct and retrograde motions of the planets; the apparent diurnal motion of the whole celestial sphere from east to west; and the different clusters of stars which are seen in our nocturnal sky at different seasons of the year. We would next consider the deductions which science has made respecting the order and arrangement of the planets which compose the Solar system; their distances from the sun and from the earth; their magnitudes; the periods of their diurnal and annual revolutions; the secondary planets, or moons, which accompany them; their eclipses; the various phenomena which their surfaces present when viewed through telescopes; the physical influence which some of them produce on the surface of our globe; and the singular appearance of those bodies called *comets*, which occasionally visit this part of our system. We would, in the next place, extend our views to the starry regions, and consider the number of stars which present themselves to the naked eye; the immensely greater number, which are discovered by telescopes; the systems into which they appear to be arranged; the facts which have been ascertained respecting *new* stars; double and treble stars; stars once visible which have now disappeared from the heavens; variable stars, whose lustre is increased and diminished at different periods of time; and the structure and position of the many hundreds of *nebulæ*, or starry systems, which appear to be dispersed throughout the immensity of creation.

All the particulars now stated, and many others which might have been specified, *considered simply as facts* which exist in the system of nature, form the appropriate and legitimate objects of natural history, and demand the serious attention of every rational intelligence who wishes to trace the perfections and agency of the

almighty Creator. To investigate the *causes* of the diversified phenomena which the material world exhibits, and the principles and modes by which many of the facts now alluded to are ascertained, is the peculiar province of natural philosophy, chemistry, and the mathematical sciences.

Amidst so vast a variety of objects as natural history presents, it is difficult to fix on any particular facts, as specimens of the interesting nature of this department of knowledge, without going beyond the limits to which I am necessarily confined in this volume. I shall content myself, in the first place, with a description of two objects, which have a reference chiefly to the vegetable kingdom, and shall then present a few details respecting *luminous and fiery meteors.* The first of these is

THE BANIAN TREE.—"This tree, which is also called the *Burr tree*, or the *Indian fig*, is one of the most curious and beautiful of



INDIAN FIG, OR BANIAN TREE.

nature's productions, in the genial climate of India, where she sports with the greatest variety and profusion. Each tree is in itself a grove; and some of them are of an amazing size and extent, and, contrary to most other animal and vegetable productions, seem to be exempted from decay. Every branch from the main body throws out its own roots; at first, in small tender fibres

several yards from the ground; these continually grow thicker, until, by a gradual descent, they reach the surface, and there striking in they increase to large trunks, and become parent trees, shooting out new branches from the tops. These in time suspend their roots, and receiving nourishment from the earth, swell into trunks, and shoot forth other branches; thus continuing in a state of progression, so long as the earth, the first parent of them all, contributes her sustenance. A Banian tree, with many trunks, forms the most beautiful walks, vistas, and cool recesses, that can be imagined. The leaves are large, soft, and of a lively green, about six inches in length; the fruit is a small fig, when ripe, of a bright scarlet, affording sustenance to monkeys, squirrels, peacocks, and birds of various kinds, which dwell among the branches.

"The Hindoos are peculiarly fond of the Banian tree; they consider its long duration, its outstretching arms, and its overshadowing beneficence, as emblems of the Deity, and almost pay it divine honours. The Brahmins, who thus 'find a fane in every grove,' spend much of their time in religious solitude, under the shade of the Banian tree; they plant it near their temples or pagodas: and in those villages where there is no structure erected for public worship they place an image under one of these trees, and there perform a morning and evening sacrifice. The natives of all castes and tribes are fond of recreating in the cool recesses, beautiful walks, and lovely vistas of this umbrageous canopy, impervious to the hottest beams of a tropical sun. It is recorded that one of these trees shaded all the town of Fort St. David and Gombroon. These are the trees under which a sect of naked philosophers, called Gymnosophists, assembled in Arian's days, and this historian of ancient Greece presents a true picture of the modern Hindoos. 'In winter,' he says, 'the Gymnosophists enjoy the benefit of the sun's rays in the open air; and, in summer, when the heat becomes excessive, they pass their time in cool and moist places, under large trees, which, according to the accounts of Nearchus, cover a circumference of *five acres*, and extend their branches so far that 10,000 men may easily find shelter under them."

"On the banks of the river Narbudda, in the province of Guzzerat, is a Banian tree, supposed by some persons to be the one described by Nearchus who commanded the fleet of Alexander the Great, and certainly not inferior to it. It is distinguished by the name of Cubbeer Burr, which was given it in honour of a famous saint. Forbes, in his 'Oriental Memoirs,' when speak-

ing of the age of such trees, states that he smoked his hookha under the very Banian beneath which part of Alexander's cavalry took shelter. High floods have at various times swept away a considerable part of this extraordinary tree; but what still remains is nearly 2000 feet in circumference, measured round the principal stems; the overhanging branches, not yet struck down, cover a much larger space; and under it grow a number of custard-apple and other fruit trees. The large trunks of this single tree amount to 350, and the smaller ones exceed 3000; every one of these is constantly sending forth branches and hanging roots to form other trunks, and become the parents of a future progeny. The Cubbeer Burr is famed throughout Hindostan, not only on account of its great extent, but also of its surpassing beauty. The Indian armies generally encamp around it; and at stated seasons solemn Jatarras, or Hindoo festivals, to which thousands of votaries repair from every part of the Mogul empire, are there celebrated. It is said that 7000 persons find ample room to repose under its shade. It has long been the custom of the British residents in India, in their hunting and shooting parties, to form extensive encampments, and spend weeks together under this delightful and magnificent pavilion, which affords a shelter to all travellers, particularly to the religious tribes of the Hindoos. It is generally filled with greenwood pigeons, doves, peacocks, and a variety of feathered songsters—with monkeys, which both divert the spectator by their antic tricks, and interest him by the parental affection they display to their young offspring, in teaching them to select their food, and to exert themselves in jumping from bough to bough,—and is shaded by bats of a large size, many of them measuring upwards of six feet from the extremity of one wing to the other. This tree affords not only shelter, but also sustenance, to all its inhabitants, being covered, amid its bright foliage, with small figs, of a rich scarlet, on which they all regale with as much delight as the lords of creation on their more costly fare, in their parties of pleasure."

The Engraving, page 153, will convey a general though imperfect idea of this singular tree, and of the manner in which the branches from the main body throw out their shoots, and form the numerous vistas which are found under its shade.

This tree, which is doubtless one of the most singular and magnificent objects in the vegetable kingdom, appears to be a world in miniature, in which thousands, both of human beings, and of the

inferior tribes that traverse the earth and the air, may find ample accommodation and subsistence. What a striking contrast does it present to the forests of trees, or mushrooms, which are perceived by the help of the microscope, in a piece of *mouldiness*—every plant of which is several hundreds of times smaller than the point of a fine needle! Yet both are the effects of the agency of the same all-wise and omnipotent Being. And what an immense variety of gradations is to be found in the vegetable world, between these two extremes—every part of the vast interval being filled up with flowers, herbs, shrubs, and trees, of every colour, form, and size, and in such vast multitudes and profusion that no man can number them!

An object which approximates in a certain degree to the one now described is mentioned in 'Staunton's Account of Macartney's Embassy to China,' page 70. It is called by Botanists, *Adansonia*, and is also known by the name of the *Monkey Bread Tree*, and was discovered in the island of St. Jago. "The circumference or girth of the base was 56 feet, which soon divided into two vast branches, the one in a perpendicular direction, whose periphery, or girth, was 42 feet, the other 26. Another, of the same species, stood near it, whose single trunk, girthing 38 feet, was scarcely noticed."

Flower and Leaf of the Monkey Bread Tree.

The only other specimen I shall exhibit to the reader has a relation both to the animal and to the vegetable kingdom. It is well known that the examination of flowers and vegetables, of every description, by the microscope, opens a new and interesting field of wonders to the enquiring naturalist. Sir John Hill has given the following curious account of what appeared on his examining a carnation:—

"The principle flower in an elegant bouquet was a carnation: the fragrance of this led me to enjoy it frequently and near. The sense of smelling was not the only one affected on these occasions: while that was satiated with the powerful sweet, the ear was constantly attacked by an extremely soft but agreeable murmuring sound. It was easy to know, that some animal within the covert must be the musician, and that the little noise must come from some little creature suited to produce it. I instantly distended the lower part of the flower, and placing it in a full light could discover troops of little insects frisking, with wild jollity, among the narrow pedestals that supported its leaves, and the little threads that occupied its centre. What a fragrant world for their habitation! What a perfect security from all annoyance, in the dusky husk that surrounded the scene of action! Adapting a microscope to take in, at one view, the whole base of the flower, I gave myself an opportunity of contemplating what they were about, and this for many days together, without giving them the least disturbance. Thus, I could discover their economy, their passions, and their enjoyments. The microscope, on this occasion, had given what nature seemed to have denied to the objects of contemplation. The base of the flower extended itself, under its influence, to a vast plain; the slender stems of the leaves became trunks of so many stately cedars; the threads in the middle seemed columns of massy structure, supporting at the top their several ornaments; and the narrow spaces between were enlarged in walks, parterres, and terraces. On the polished bottoms of these, brighter than Parian marble, walked in pairs, alone or in larger companies, the winged inhabitants; these, from little dusky flies, for such only the naked eye would have shown them, were raised to glorious glittering animals, stained with living purple, and with a glossy gold, that would have made all the labour of the loom contemptible in the comparison.—I could, at leisure, as they walked together, admire their elegant limbs, their velvet shoulders, and their silken wings; their backs vying with the empyrean in its blue; and their eyes, each formed of a thousand others, out-glittering the little planes on a brilliant; above description, and too great almost for admiration. I could observe them here singling out their favourite females; courting them with the music of their buzzing wings, with little songs, formed for their little organs, leading them from walk to walk, among the perfumed shades, and pointing out

to their taste, the drop of liquid nectar, just bursting from some vein within the living trunk—here were the perfumed groves, the more than mystic shades of the poet's fancy realised. Here the happy lovers spent their days in joyful dalliance, or in the triumph of their little hearts, skipped after one another, from stem to stem, among the painted trees, or winged their short flight to the close shadow of some broader leaf, to revel undisturbed in the heights of all felicity."

This picture of the splendour and felicity of insect life may to certain readers appear somewhat overcharged. But those who have been much in the habit of contemplating the beauties of the animal and vegetable world, through microscopes, can easily enter into all the views which are here described. I have selected this example for the purpose of illustrating the unbounded goodness of the Creator, in the vast profusion of enjoyment he has communicated even to the lowest tribes of animal existence, and as a specimen of those invisible worlds which exist beyond the range of our natural vision. For it appears, that there is a gradation of worlds downwards as well as upwards. However small our globe may appear when compared with the sun, and with the immensity of starry systems which lie dispersed through the infinity of space, there are worlds filled with myriads of living beings, which, in point of size and extent, bear as small a proportion to the earth as the earth bears to the vast assemblage of the celestial worlds. A single flower, a leaf, or a drop of water, may appear as large, and as diversified in its structure, to some of the beings which inhabit it, as the whole earth appears to the view of man: and a thousand scenes of magnificence and beauty may be presented to their sight, of which no distinct conception can be formed by the human mind. The many thousands of transparent globes, of which their eyes are composed, may magnify and multiply the objects around them without end, so that an object scarcely visible to the eye of man, may appear to them as a vast extended universe.

"Having examined," says St. Pierre, "one day, by a microscope, the flowers of thyme, I distinguished in them, with equal surprise and delight, superb flagons with a long neck, of a substance resembling the amethyst, from the gullets of which seemed to flow ingots of liquid gold. I have never made observations of the *corolla*, simply of the smallest flower, without finding it com-

posed of an admirable substance, half transparent, studded with brilliants, and shining in the most lively colours. The beings which live under a reflex thus enriched must have ideas very different from ours, of light, and of the other phenomena of nature. A drop of dew, filtering in the capillary and transparent tubes of a plant, presents to them thousands of cascades; the same drop fixed as a wave on the extremity of one of its prickles, an ocean without a shore; evaporated into air, a vast aerial sea.—It is credible, then, from analogy, that there are animals feeding on the leaves of plants, like the cattle in our meadows and on our mountains, which repose under the shade of a down imperceptible to the naked eye, and which, from goblets formed like so many suns, quaff nectar of the colour of gold and silver."

Thus it appears that the universe extends to infinity on either hand; and that wherever matter exists, from the ponderous globes of heaven down to the invisible atom, there the almighty Creator has prepared habitations for countless orders of existence, from the seraph to the animalcule, in order to demonstrate his boundless beneficence, and the infinite variety of modes by which he can diffuse happiness through the universal system.

> "How sweet to muse upon his skill, display'd—
> Infinite skill!—in all that he has made,
> To trace in Nature's most minute design,
> The signature and stamp of Power Divine;
> Contrivance exquisite, expressed with ease
> Where unassisted sight no beauty sees;
> The shapely limb and lubricated joint,
> Within the small dimensions of a point;
> Muscle and nerve miraculously spun,
> His mighty work; who speaks and it is done:
> The Invisible in things scarce seen reveal'd;
> To whom an atom is an ample field!"—Cowper.

Luminous and Fiery Meteors.—We may give another example of some facts connected with Natural history—namely, the striking phenomena exhibited by certain luminous and fiery meteors. Although we are not yet acquainted with all the causes which produce such phenomena, or the principles in nature with which they are connected, yet it may be interesting to be acquainted with the appearances they present; and it is the province of natural history chiefly to describe the *facts* in relation to the economy of

nature, leaving the investigation of their causes to the natural and experimental philosopher.

The Aurora Borealis.—This is one of the most splendid and striking spectacles to be seen in the visible heavens, especially when its variegated coruscations cover, as they sometimes do, the whole face of the sky. When it first began to exhibit its more splendid aspect, as in March 1716, it attracted universal attention, and, among the vulgar, it excited no small degree of wonder and alarm, being considered as prognostic of the introduction of war and commotion, and a foreign race of princes.

AURORA BOREALIS.

In the temperate climates, this phenomenon generally appears as a faint, beautiful yellow light, somewhat similar to the morning or evening twilight. It generally appears to rise from a kind of dark cloud or collection of vapours, which runs along from the north to the east and west, and is elevated from 10 to 20 or 30 degrees above the horizon. The luminous matter above this cloud is generally steady and uniform, but from this luminous curve or border, there are streams that dart up towards the zenith with great rapidity. Sometimes it is perpetually changing its altitude, and seems to roll like the sea in a storm. The coruscations are frequently suddenly extinguished and removed, and are continually shifting their places. Sometimes they rise only a few degrees and with a faint light; at other times they mount with a broad and bright beam to the zenith. They commonly appear about the twilight near the horizon, of a dim colour approaching to yellow, continuing sometimes in that state for an hour or two without any sensible motion; after which they break out into streams of stronger light spreading into columns, and altering slowly into ten thousand different shapes, varying their colours from all the tints of yellow to the obscurest

russet. They sometimes cover the whole hemisphere, and then make the most brilliant appearance. Their motions at those times are most amazingly quick, and they astonish the spectators with the rapid change of their form. They break out in places where none were seen before, skimming briskly along the heavens—are suddenly extinguished, and leave behind an uniformly dusky track. This again is brilliantly illuminated in the same manner, and as suddenly left a dull blank. They have generally a strong tremulous motion from end to end, which continues till the whole evanishes.

Such are the general phenomena exhibited by the aurora borealis in our temperate climate.—I shall mention only the following particular instance of which I was a spectator, as it appeared in the vicinity of Dundee. It happened on the evening of the 17th November, 1835. The coruscations first began to appear a little before 9 o'clock, when the sky which had been previously darkened by a variety of clouds floating over its concave, assumed in a short time all the brightness which usually appears in a moonlight evening. About 10 o'clock, and for an hour or two afterwards, the aurora shone in its greatest splendour. At this time extensive coruscations or streams of light, more than 40 degrees in length, appeared to issue from a central point, a little to the south of the zenith, and to extend themselves in every direction, to the east, the south, and the west, like the meridians on a terrestrial globe. But the most singular appearance exhibited by this aurora was that of a number of streams of light, of *a dark red colour*, like blood, and resembling expansive sheets of fire, which were seen in all directions, mingling their streams, as it were, with the more brilliant coruscations, which gave to the whole sky an air of terrific grandeur. Appearances of this kind are recorded in history, and appear to have given rise to many superstitious terrors, and to have been considered as prognostics of war, famine, pestilences, and other calamities. This display of the aurora appears to have been visible over the whole island of Great Britain and the adjacent countries. For, a few days afterwards, the London Journals announced that the policemen of that city were hurrying to and fro, through all the avenues of the metropolis in search of *fires*, which they imagined had burst out from every quarter of the city; and their alarm did not subside till the morning light appeared. This phenomenon continued during the whole night till at least 4 o'clock next morning. At 6, all was dark like a cloudy morning

without the moon. During the whole time of its continuance there appeared as much brightness over the terrestrial surface as at full moon when that orb is obscured by clouds.

About a month before the time stated above, the 'Bath Herald' described an extraordinary phenomenon, as having been seen in the heavens by not less than thirty or forty individuals, which filled them with no small degree of consternation. It was the appearance of a regiment of horsemen, with swords drawn, every trooper being distinctly visible, and the whole performing their evolutions as in the field of battle. A woman in the village was so terrified at the spectacle, that she had not recovered from her fright at the time the account was written, and was found to be really seriously indisposed. Whether this phenomenon was an optical illusion, or such a display of the aurora borealis as above described, remains to be considered; but there can be little doubt that many of the extraordinary appearances which have been said to have been seen in the sky have arisen from some peculiar and extraordinary displays of the Northern lights.

The aurora borealis appears more frequent and much more resplendent in the polar regions than in our climate. The splendour and the motions of its coruscations are far more striking than with us, as, in general, we see only the extremities of these northern phenomena. Maupertuis and his associates, who went to measure an arc of the meridian in Lapland, continued to prosecute their nice and difficult work, by the aid of this light long after the sun had left them. He says that "it is sufficient along with the light of the heavenly bodies for most of the occasions of life." "No sooner are the short days closed than the fires of a thousand figures and colours light the sky as if intended to make up for the absence of the sun. These lights are perpetually varying. Sometimes they begin in the form of a great scarf of bright light, with its extremities upon the horizon, which with a motion resembling that of a fishing net, glides swiftly up the sky, preserving a direction, nearly perpendicular to the meridian; and commonly, after these preludes, all the lights unite at the zenith, and form the top of the crown. The motion of these meteors is commonly that of two standards waving in the air, and the different tints of their light give them the appearance of so many streamers of changeable silk." "I saw," says Maupertuis, "a phenomenon of this kind that, in the midst of all the wonders to which I was now every

day accustomed, excited my admiration. To the south, a great space of sky appeared tinged with so lively a red, that the constellation of Orion looked as if it had been dipped in blood. This light, which was at first stationary, soon moved, and changing into other colours, violet and blue, settled into a dome, the top of which stood a little to the south-west of the zenith. In this country where there are lights of so many different colours, I never saw but two that were red, and such are always taken as presages of some misfortune."

In the northern districts of Siberia, the aurora begins with single bright pillars rising in the north and north-east, which, gradually increasing, comprehend a large space in the heavens, rush about from place to place with incredible velocity, and at last, cover almost the whole sky up to the zenith, and produce an appearance as if a vast tent was expanded in the heavens, glittering with gold, rubies, and sapphire. "A more beautiful spectacle (says Gmelin) cannot be painted. But whoever should see such a northern light for the first time could not behold it without terror. For, however fine the illumination may be, it is attended, as I have learned from the relations of many persons, with such a hissing, crackling, and rushing noise through the air, as if the largest fireworks were playing off. To describe what they then hear, they make use of an expression which signifies "the raging host is passing." It is said that the hunters are often overtaken by these northern lights, and that their dogs are then so much frightened that they will not move, but lie obstinately on the ground till the noise has passed."

Much has been said respecting the noises to which Gmelin here adverts, and some philosophers have been disposed to call the fact in question. But this fact has been asserted by so many that it would appear rash to deny it, although we may be unable to account for its cause. It is affirmed on good evidence, that such noises nave been heard, accompanying a splendid display of the aurora, by persons in Hudson's Bay; and by those engaged in the Greenland fisheries, and even in more southern latitudes, something of this kind has been perceived. Nairne, the celebrated Electrician, states with great confidence that at a time when the coruscations of the aurora were very remarkable in England, they were attended with a hissing or whizzing sound; and Mr. Cavallo declares that he has repeatedly heard a crackling noise proceeding from the same cause. Dr. Belknap, of America, when alluding

to the aurora, as it appeared in New Hampshire in 1719, says, "In a calm night, and in the intervals between the gentle flows of wind, an attentive ear, in a retired situation, may perceive it to be accompanied by a sound like that made by a silk handkerchief rubbed along the edge by a quick motion of the thumb and finger."

It appears that, towards the *southern* regions of the globe this phenomenon likewise makes a brilliant appearance. Mr. Forster, who sailed round the world with Captain Cook, assures us that he observed the aurora when in high southern latitudes, though with phenomena somewhat different from those which are seen in this country. On the 17th February 1773, when in latitude 58° South, "a beautiful phenomenon was observed during the preceding night, which appeared again this and the following nights. It consisted of long columns of a clear white light, shooting up from the horizon to the eastward, almost to the zenith, and gradually spreading on the whole southern part of the sky, and though similar to the northern lights of our hemisphere, yet differed from them in being always of a whitish colour. The sky was generally clear when they appeared, and the air sharp and cold."

In the brilliant display of this phenomenon in the north polar regions, there is a manifestation of divine goodness which we ought not to overlook. In those regions the sun is absent for weeks and months together. How dreary would be the condition of the inhabitants were they left in absolute darkness, without any species of light to cheer their dwellings and enable them to move about in safety from place to place for such a length of time! But the aurora borealis comes to their aid, just at the season when they most stand in need of its light and brilliancy, and diffuses over their frozen landscapes and humble dwellings a lustre equal to that of the full moon shining in all her splendour. For Maupertuis informs us, as above stated, that "he could pursue his difficult work, by the aid of this light long after the sun had left them," and that "it is sufficient, along with the light of the heavenly bodies, for most of the occasions of life." So that, in the absence of the sun, the inhabitants of the northern parts of Lapland, Greenland, and Siberia, may prosecute their journeys, and engage in active employments in the open air, with as much ease as we can do under the clear light of the moon—one evidence among others, that "the tender mercies of the Creator are diffused over all his works."

LUMINOUS ARCHES.—Sometimes it happens, though not frequently, that during an aurora, or a little before it makes its appearance, a broad and nearly permanent luminous arch is seen rising from the magnetic east, and passing a little south from the zenith, at right angles to the direction of the streamers. A splendid phenomenon of this kind I had an opportunity of observing, from the Castle Hill of Edinburgh, on the 11th September, 1814, of which an account was published in 'The Monthly Magazine' for December, 1814. It appeared a little before 8 o'clock in the evening, and extended in a direction, as nearly as I could ascertain, from East by North to West by South, and consequently was nearly at right angles to the magnetic meridian. Its elevation in its highest point, was between 50 and 60 degrees above the southern point of the horizon. Its breadth, which was nearly equal throughout its extent, was somewhat greater than that of a common rainbow; and its brilliancy considerably exceeded that of the *Milky Way*. The whole arch seemed to have a slow motion from the zenith towards the southern horizon, and grew fainter in its lustre till it gradually evanished. About the time when it evanished, the most elevated part of its southern edge was about half a degree above *Altair*, the principal star in the constellation Aquila, which was then on the meridian at an altitude of about 42° 20′. It evanished about half past 8, according to the time pointed out by the public clocks of Edinburgh. The sky was extremely clear, except towards the northern parts of the horizon. There was evidently an appearance of aurora in the north, but its coruscations were hid by a few interposing clouds; their outskirts, however, presented the appearance of an irregular luminous zone, and the sky appeared to be as much illuminated as when the moon is about six days old, and above the horizon, the luminous arch, however, seemed to have no *immediate* connection with the aurora. Between 10 and 11 o'clock the same evening brilliant coruscations of the aurora made their appearance. It afterwards was found that the same phenomena were observed at Perth, Dundee, Forfar, and the adjacent districts, and likewise in the middle and southern counties of England; which shows, that the phenomenon—whatever was its nature—was elevated at a great distance above the surface of the earth.

Mr. Cotes, in his 'Hydrostatical and Pneumatical Lectures,' published in 1738, describes a similar phenomenon in the following

words. "A surprising appearance was seen here (at Cambridge) about 10 o'clock at night, and at other very distant places, on the 20th March, 1706. It was a semicircle of light of about two-thirds of the ordinary breadth of the milky way, but much brighter. The top of it passed very near our zenith, inclining 4 or 5 degrees to the north; it crossed the horizon, at a very small distance from the west towards the south, and again about as far from the east towards the north. There was at the same time an aurora borealis. A friend of mine saw the same appearance in Lincolnshire, at the distance of about 70 miles north of Cambridge; the semicircle seemed to him to be in the plane of the equator. From these two observations compared together, it is easy to collect that the matter from which that light proceeded was elevated above the earth's surface between 40 and 50 miles."

I have seen several of these luminous arches since the period stated above, and have uniformly found their direction to be at right angles to the magnetic meridian; but some of them appeared much broader than that which was seen in September, 1814; and they had all a slow motion from the zenith towards the southern horizon, and were accompanied with appearances of the aurora, which seems to indicate that they are peculiar modifications of that phenomenon, and intimately connected with it.—As to the *height* of this phenomenon above the surface of our globe, there have been very different estimates, varying from 50 to 1000 miles. Euler supposed the height of the aurora borealis to be more than 1000 miles above the earth. Boscovich reckoned the height of one which he observed in December, 1737, to have been 825 miles high. Bergman reckons the average height to be 460 miles. Mairan supposed it to be 260 leagues; but our countryman, Mr. Dalton, in his 'Meteorological Essays,' makes it only about 150 miles above the earth's surface. It is probable that the lowest estimates approach nearest to the truth.—In reference to the luminous arches, this point might be very nearly determined, were observers in different places carefully to note the exact time when the middle or edges of the arch seemed to coincide with any remarkable star, by which the parallax of the object might be nearly ascertained, and from the difference of latitude and the bearings of the respective places of observation, a base-line would be found, by which the perpendicular altitude might be ascertained. But in this case the clocks or watches in the different places of observation ought to be accurately adjusted to mean time.

As to the *cause* which operates in the production of the aurora, there has been a great variety of opinions, which it would be too tedious to enumerate. The most plausible theory is that which ascribes the cause to the operation of electricity. It is found that, when the electric fluid is made to pass through a vacuum, or a portion of air rarified to the same degree as that in the upper regions of the atmosphere, a luminous appearance is produced, entirely resembling the coruscations of the aurora borealis, and which continues for a considerable time. With respect to the variations of colour which are found in the aurora, these may be ascribed to the different degrees of rarefaction of the air; for the same electricity that appears white in a very rare medium, becomes blue, purple, or red, in a medium of increased density, as is proved by various electrical experiments. It is therefore highly probable that electricity is at least one of the agents which operates in the production of this phenomenon. The brilliancy of the light of the aurora, the rapidity of its motions, and the instantaneous changes of its form which it undergoes, all point to this powerful agent as one of the causes of these phenomena. But it has likewise a connection with the magnetic fluid, as appears from the position of the luminous arches, and likewise from the disturbance it causes to the magnetic needle, in producing oscillations of the horizontal needle, sometimes to the eastward and then to the westward of the mean daily position—and from the needle returning again to its former station, when the aurora has ceased. It is now, however, pretty well ascertained that electrical, galvanic, and magnetical phenomena proceed from a modification of the same general principle. But, how the electric matter is produced in those higher regions where it operates, and why it displays itself only at certain seasons, are circumstances with which we are but imperfectly acquainted.

Fire Balls.—These are a kind of luminous bodies generally appearing at a great height above the earth, with a splendour surpassing that of the moon, and sometimes presenting an appearance equal to her apparent size. When seen in our northern region, they generally proceed from north to south with great velocity, frequently breaking into several smaller ones, sometimes disappearing in silence, and sometimes vanishing with a loud report.—These luminous appearances, in all probability, constitute one part of the ancient prodigies—blazing stars or comets—which last they frequently resemble, in being attended with a train.

The first *accurate* account we have of this description of meteors is that of one which was observed by Dr. Halley and several other philosophers in the year 1719. From the slight observations they could take of its course among the stars, the perpendicular height of this body was computed to have been about 70 miles, its diameter at 2800 yards, or more than a mile and a half, and its velocity 350 miles in a minute. But the most remarkable of these on record appeared on the 18th of August, 1783, about 9 o'clock in the evening. It was seen towards the northward of Shetland, and took a southerly direction for an immense space, being observed as far as the southern provinces of France, and one account says that it was also seen at Rome. During its course, it appears frequently to have changed its shape; sometimes appearing in the form of one ball, and sometimes of two or more, sometimes with a train, and sometimes without one. It passed over Edinburgh nearly in the zenith, and had then the appearance of a well-defined round body, *extremely luminous*, and of a greenish colour, the light which it diffused on the ground giving likewise a greenish cast to objects. After passing the zenith, it was attended with a train of considerable length, which, continually augmenting, at last obliterated the head entirely, so that it looked like a wedge, flying with the obtuse end foremost. The motion was not apparently swift, on account of its great height, though in reality it must have moved with great swiftness, on account of the vast space it travelled over in a short time. At Greenwich, we are told, that "two bright balls, parallel to each other, led the way, the diameter of which appeared to be about two feet, and were followed by an expulsion of eight others. Between each two balls a luminous serreted body extended, and at the last a blaze issued which terminated in a point. The balls were tinted first by a pure bright light, then followed a tender yellow, mixed with azure, red, green, etc., which, with a coalition of bolder tints, and a reflection from the other balls, gave the most beautiful rotundity and variation of colour that the human eye could be charmed with. The sudden illumination of the atmosphere, and the form and singular transition of this bright luminary tended much to make it terrific and awful: nevertheless, the amazing vivid appearance of the different balls, and other rich connective parts, not easy to delineate, gave an effect equal to the rainbow in the full zenith of its glory."

It is among my earliest recollections, having seen and been

dreadfully alarmed at the appearance of the fire-ball now described. When a child, I was out in my father's garden in Dundee with the maid, who was folding up some linens which had been drying, when looking towards the north, the maid exclaimed, "You have never seen lightning before—there's lightning!"—when in an instant, the whole body of the meteor appeared in all its brightness, which produced such a sudden terror and alarm, that we both fell prostrate to the ground, where we remained for some time, supposing the earth was to be burnt up and ourselves destroyed. My father and mother saw its light from an upper window, as they were taking some refreshment after a journey, which they described as approximating to the light of the sun, and which produced universal amazement and terror in all who beheld it.

The height of this fire-ball above the earth was reckoned at not less than 90 miles; its diameter was estimated at nearly two miles, and its velocity at about 1000 miles in a minute—Five balls in appearance similar to those now described, though vastly inferior in size, have been sometimes observed at the surface of the earth. Of this kind Dr. Priestly mentions one that was seen on board the Montague, 4th November, 1749, which appeared as big as a large millstone, and broke with a violent explosion. Such perhaps are those which sometimes appear in the time of thunder, and frequently produce mischievous effects. One of these is mentioned as having fallen in a serene evening in the island of Jamaica, exploding as soon as it touched the surface of the ground, and making a considerable hole in it. Another is mentioned as rolling along the surface of the sea, then rising and striking the top-mast of a man-of-war, and damaging the ship. Some time ago there appeared an electrical cloud at Java, in the East Indies, from which, without any thunder-storm, there issued a vast number of fire-balls which produced incredible mischief.

As to the *cause* which produces these phenomena, there have been different opinions entertained. Dr. Halley imagined that such meteors do not consist of one single body but of a train of sulphurous vapours extending a vast way through the atmosphere, and being kindled at one end display the luminous appearance in question by the fire running from one end of the train to the other. But the most common and probable opinion now is, that the fire-balls are great bodies of electric matter moving from one part of the heavens, where, to our conception, it is superabundant, to another

where it is deficient. It is supposed that there must be a constan current of electric matter through the bowels of the earth from the equator to the poles, and from the poles to the equator through the atmosphere, and that the great meteors now described serve for the keeping up of the equilibrium, in this great atmospherical current, while the smaller ones answer a like purpose in the general mass of electric matter dispersed over the surface of the earth, and therefore are seen to move in all directions, as the equilibrium happens to require them in different parts.—As the large fire-balls, in their course, constantly move either from the north or north-west quarter of the heavens, or nearly in the direction of the magnetic meridian, it is highly probable that they have likewise a relation to the magnetic fluid, and other causes of which we are ignorant may combine to produce these phenomena.

Shooting or Falling Stars.—These are meteors which dart through the sky, in the form of stars, generally accompanied with a train of light. These phenomena were formerly considered as merely atmospherical meteors originating in the inflammation of a quantity of hydrogen gas, by means of electricity. But, in consequence of recent observations, they are now considered as bodies of a very different description. From observations made at Breslau and other places by professor Brandes and many of his pupils, the height of some shooting stars has been calculated at 500 English miles; and the rate at which they move at not less than 36 miles in a second, which is nearly double the rate of the earth's motion round the sun; but as it has been ascertained that shooting stars usually move in a direction contrary to that of the earth's motion, the real motion of these bodies will only be about 18 miles in a second, which is, however, a rate of velocity extremely rapid, more than that of any planet in the Solar system, with the exception of Mercury and Venus.

A particular degree of interest has been excited in relation to these phenomena, in consequence of showers of these stars having been lately observed in North America and other regions of the globe. On the night of the 12th and the morning of the 13th November, 1833, a most extraordinary shower of these meteors was observed at Boston, Hartford, New York, Philadelphia, and other places of the United States which created universal wonder and astonishment. Thousands of these bodies appeared to sweep along through the sky at once, and in continued succession for

several hours, so that almost the whole visible canopy of the heavens seemed to be in a blaze. They succeeded each other at so short intervals that it was impossible to count them, and the most moderate calculations estimated their number at not less than *hundreds of thousands.* At the observatory of Boston their number was considered as equalling one half of the flakes which fill the air in an ordinary fall of snow. When their numbers were diminishing 650 stars were counted in 15 minutes in a circumscribed part of the heavens, which did not comprise a tenth part of the visible horizon, and these did not amount to two-thirds of the whole number seen, which was about 900, and it was supposed that, if the whole hemisphere could have been surveyed by one observer, 36,000 would have been seen in the course of an hour. This striking phenomenon continued during the space of seven hours, and it was reckoned that the whole number of shooting stars seen at Boston was upwards of 240,000.

The following is an abridged account of these extraordinary phenomena, taken from the 'New York Commercial Advertiser' of November 13th, 1833.—"The sky was remarkably clear on the night of this remarkable phenomenon. Before 12 o'clock the shooting stars were observed to fall with unusual frequency and splendour. From four to six in the morning they were most numerous and refulgent. Not a cloud obscured the broad expanse, and millions of meteors sped their way across it on every point of the compass. Were it possible to enumerate them in the swiftness of their arrowy haste, we might venture to say that for the space of two hours, intervening between four and six, more than 1000 per minute might have been counted. Their coruscations were bright, gleamy, and incessant, and they fell as thick as the flakes in the early snows of December. In one instance, we distinctly heard the explosion of a meteor that shot across to the north-west, leaving a bright and luminous tract; and witnessed another which left a path of light that was clearly discernible for more than ten minutes after the ball had exploded.—Compared with the splendour of this celestial exhibition, the most brilliant rockets and fireworks of art bore less relation than the twinkling of the most tiny star to the broad glare of the sun. The whole heavens seemed in motion, and never before has it fallen to our lot to observe a phenomenon so magnificent and sublime."—It is worthy of particular notice that the point from which the meteors seemed to emanate was

observed, by those who fixed its position among the stars, to be in the constellation *Leo*, and according to their concurrent testimony, this *radiant point* was stationary among the stars during the whole period of observation—that it did not move along with the earth in its diurnal revolution *eastward*, but accompanied the stars in their apparent progress westward, which proves the elevation of the meteors to be far beyond our atmosphere.

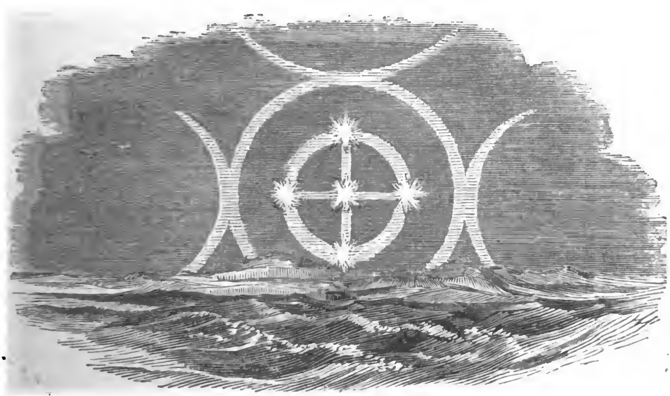
Similar phenomena have been observed in other regions of the globe, and it is remarkable that they have been generally seen on the 12th and 13th November, and are now distinguished by the name of "The November Meteors." On the night of the 12th November, 1779, a phenomenon of this kind was seen at Cumana, in South America, when thousands of meteors, colids, fireballs, or falling stars, as they were variously denominated, succeeded each other during four hours. Similar appearances were beheld in 1799 by Humboldt in America, by the Moravians in Greenland, aud by various individuals in Germany, on the 12th and 13th of November; and in 1832, by Captain Hammond, at Mocha, on the Red sea, on the morning of the 13th November.—These circumstances have led to the conclusion, which has been adopted by some, that there are myriads of small bodies existing within the limits of the Solar system, whose orbits every year, about the 12th and 13th November, approach near the earth's orbit.—Dr. Olmsted, professor of mathematics and natural philosophy, in Yale College, New Haven, who has entered into minute investigations on this subject, has arrived at the following conclusions:—

1. That the meteors of November 13 had their origin beyond the limits of our atmosphere. 2. That the height of the place whence the meteors emanated was about 2238 miles above the surface of the earth. 3. That the meteors fell towards the earth, being attracted to it by the force of gravity. 4. That they fell towards the earth in straight lines, and in directions which, within considerable distances, were nearly parallel with each other. 5. That they entered the earth's atmosphere with a velocity equal to about 4 miles per second,—or more than ten times greater than the maximum velocity of a cannon ball 6. The meteors consisted of combustible matter, and took fire and were consumed in traversing the atmosphere. 7. Some of the larger meteors must have been bodies of great size. Some of them appeared larger than the full moon rising; and such a body seen at the distance of 110

miles behoved to have been one mile in diameter. 8. The meteors were constituted of light and transparent materials; otherwise then momentum would have been sufficient to enable them to make their way through the atmosphere to the surface of the earth.—The ultimate conclusion to which professor Olmsted arrives is the following:—"That the meteors of November 13 consisted of portions of the extreme parts of a nebulous body which revolves around the sun in an orbit interior to that of the earth, but little inclined to the plane of the ecliptic, having its aphelion near to the earth's path, and having a periodic term of 182 days nearly."

The above conclusions are deduced from a great variety of observations, reasonings, and investigations, which occupy about 80 pages of professor Silliman's Scientific Journal.

The meteors to which I have now directed the attention of the reader form, on the whole, an interesting subject of contemplation. Some of them have evidently their origin and their range far be-



PARHELIA, OR MOCK SUNS.

yond the limits generally assigned to our atmosphere, and proceed from the operation of causes with which we are but imperfectly acquainted.—The November meteors seem to unfold to our view a

new species of planetary bodies within the range of our system, which must subserve some wise purposes of the Creator in the kingdom of nature. What these purposes are is beyond the range of our present knowledge to determine. But we may learn, from some of the facts above detailed, that, if the universe were not under the superintendence of a wise and benevolent Being, our world might be subjected to many disasters from unseen causes and unknown bodies, from which we have hitherto been protected. Had the meteors to which we have now adverted consisted of solid bodies, and made their way to the earth, thousands of human habitations might have been shattered to pieces, and ten thousands of their inhabitants deprived of life. But He who rules among the orbs of heaven and among the inhabitants of the earth has arranged the elements of nature, and the motions of all the bodies in the material world, in such a manner as, on the whole, to promote the happiness of his creatures, for "his tender mercies are over all his works." Were there no supreme, intelligent, and benevolent ruler of the universe, and were the powers we behold in operation in the system of nature to act at random, we should feel altogether uncertain of the continuance of our present enjoyments, and should have no security that the fabric of universal nature would not be dissolved or run into confusion.

With regard to the *religious* tendency of the study of Natural History, it may be remarked, that as all the objects which it embraces are the *workmanship of God*, the delineations and descriptions of the Natural historian must be considered as "the history of the operations of the Creator;" or, in other words, so far as the science extends, "the history of the Creator himself;" for the marks of his incessant agency, his power, wisdom, and beneficence, are impressed on every object, however minute, throughout the three kingdoms of nature, and throughout every region of earth, air, and sky. As the Deity is invisible to mortal eyes, and cannot be directly contemplated by finite minds, without some material medium of communication, there are but two mediums with which we are acquainted by which we can attain a knowledge of his nature and perfections. These are, either the *facts* which have occurred in the course of his providential dispensations towards our race, since the commencement of time, and the moral truths connected with them—or the facts which are displayed in the economy of nature. The first class of facts is recorded in the sacred history,

and in the annals of nations; the second class is exhibited in the diversified objects and motions which appear throughout the system of the visible universe. The one may be termed the *Moral History*, and the other the *Natural History* of the operations of the Creator. It is obviously incumbent on every rational being to contemplate the Creator through both these mediums, for each of them conveys its distinct and peculiar revelations; and, consequently, our perceptions of Deity through the one medium does not supersede the necessity of our contemplating him through the other. While, therefore, it is our duty to contemplate the perfections, the providence, and the agency of God, as displayed in the Scripture revelation, it is also incumbent upon us to trace his attributes in the system of Nature, in order that we may be enabled to contemplate the eternal Jehovah, *in every variety of aspect* in which he has been pleased to exhibit himself in the universe he has formed.

The visible creation may be considered as a permanent and sensible manifestation of Deity; intended every moment to present to our view the unceasing energies of Him "in whom we live and move." And if the train of our thoughts were directed in its proper channel, we would perceive God in every object and in every movement; we would behold him operating in the whirlwind and in the storm; in the subterraneous cavern and in the depths of the ocean; in the gentle rain and the refreshing breeze; in the rainbow, the fiery meteor, and the lightning's flash; in the splendours of the sun and the majestic movements of the heavens, in the frisking of the lambs, the songs of birds, and the buzz of insects; in the circulation of our blood, the movements of our joints, the motion of our eye-balls, and in the rays of light which are continually darting from surrounding objects, for the purposes of vision. For these and ten thousand other agencies in the system of nature are nothing else but the voice of Deity proclaiming to the sons of men, in silent but emphatic language, "Stand still, and consider the wonderful works of God."

If then it be admitted that the study of nature is the study of the Creator—to overlook the grand and beautiful scenery with which we are surrounded, or to undervalue any thing which infinite wisdom has formed, is to overlook and contemn the Creator himself. Whatever God has thought proper to create, and to present to our view in the visible world, it becomes man to study and con-

template, that from thence he may derive motives to excite him to the exercise of reverence and adoration, of gratitude and praise. In so far as any individual is unacquainted with the various facts of the history of nature, in so far does he remain ignorant of the manifestations of Deity; for every object on the theatre of the universe exhibits his character and designs in a different point of view. He who sees God only as he displays himself in his operations on the earth, but has never contemplated the firmament with the eye of reason, must be unacquainted with those amazing energies of eternal power which are displayed in the stupendous fabric and movements of the orbs of heaven. He who sees God only in the general appearances of nature, but neglects to penetrate into his minute operations, must remain ignorant of those astonishing manifestations of Divine wisdom and skill which appear in the contrivances, adaptations, and functions of the animal and the vegetable kingdoms. For the more we know of the work, the more accurate and comprehensive will be our views of the intelligence by whom it was designed; and the farther we carry our investigations of the works of God, the more admirable and astonishing will his plans and perfections appear.

In short, a devout contemplation of the works of nature tends to ennoble the human soul, and to purify and exalt the affections. It inspires the mind with a relish for the beauty, the harmony, and order, which subsist in the universe around us—it elevates the soul to the love and admiration of that Being who is the Author of all our comforts and of all that is sublime and beneficent in creation, and excites us to join with all holy beings in a chorus of praise to the God and Father of all. For they

> "Whom nature's works can charm, with God himself
> Hold converse, grow familiar day by day
> With his conceptions, act upon his plan,
> And form to his the relish of their souls."

The man who surveys the vast field of nature with the eye of reason and devotion, will not only acquire a more comprehensive view of that illimitable power which organized the universe, but will find his sources of enjoyment continually increased, and will feel an ardent desire after that glorious world where the vail which now hides from our sight some of the grandest manifestations of Deity will be withdrawn, and the wonders of Omnipotence be displayed in all their splendour and perfection.

In conformity with these sentiments, we find the inspired writers, in numerous instances, calling our attention to the wonders of creating power and wisdom. In one of the first speeches in which the Almighty is introduced as addressing the sons of men, and the longest one in the Bible,[1] our attention is exclusively directed to the subjects of Natural History; the whole address having a reference to the economy of Divine wisdom in the arrangement of the world at its first creation—the wonders of the ocean, and of light and darkness—the phenomena of thunder and lightning, rain, hail, snow, frost, and other meteors in the atmosphere—the intellectual faculties of man, and the economy and instincts of quadrupeds, birds, fishes, and other tribes of animated existence. Indeed, the greater part of the sublime descriptions contained in the book of Job has a direct reference to the agency of God in the material creation, and to the course of his providence in relation to the different characters of men; and the reasonings of the different speakers in that sacred drama proceed on the supposition that their auditors were intimately acquainted with the varied appearances of nature, and their tendency to exhibit the character and perfections of the omnipotent Creator. We find the Psalmist, in Psalm civ, employed in a devout description of similar objects, from the contemplation of which his mind is raised to adoring views of their almighty Author; and, from the whole of his survey, he deduces the following conclusions:—"How manifold are thy works, O Lord! *In wisdom* thou hast made them all! The earth is full of thy riches; so is this great and wide sea, wherein are things creeping innumerable, both small and great beasts. The glory of the Lord shall endure for ever; the Lord shall rejoice in all his works."[2] I will sing unto the Lord

[1] Job, chaps. xxxviii, xxxix, xl, xli.

[2] The *glory* of the Lord, in this passage, denotes the display of his perfections in the material universe; and the declaration of the inspired writer plainly intimates, that this display will continue *for ever*, and will remain as an object of unceasing contemplation to all intelligencies, and as an eternal monument of his power and wisdom. For although the earth and the aerial heavens will be changed at the close of that dispensation of Providence which respects our world, yet the general frame of the universe, in its other parts, will remain substantially the same; and not only so, but will, in all probability, be perpetually increasing in magnitude and grandeur. And the change which will be effected in respect to the terraqueous globe and its appendages will be such that Jehovah will have reason to "rejoice" in this as well as in all his other works.

as long as I live; I will sing praises to my God while I have my being."

But in order to enter into the spirit of such sublime reflections, we must not content ourselves with a superficial and cursory view of the objects and operations of nature,—we must not think it sufficient to acquiesce in such vague propositions as these: "The glory of God is seen in every blade of grass, and every drop of water; all nature is full of wonders, from the dust of the earth to the stars of the firmament." We must study the works of creation with ardour, survey them with minute attention, and endeavour to acquire a *specific* and *comprehensive* knowledge of the Creator's designs. We must endeavour to acquire a knowledge of the particular modes, circumstances, contexture, configurations, adaptations, structure, functions, and relations of those objects in which benevolence and design conspicuously appear—in the animal and the vegetable world, in the ocean, the atmosphere, and the heavens; that the mind may be enabled to draw the conclusion with full conviction and intelligence—"*In wisdom thou hast made them all!*" The pointed interrogatories which Jehovah addressed to Job evidently imply that Job had previously acquired an intimate acquaintance with the works of nature. It seems to be taken for granted, as a matter of course, that he had made himself acquainted with the general range of facts in the visible creation; and the intention of the several questions presented to his consideration evidently was, to impress him with a sense of his own impotency, and to lead him to the investigation of the wonders of creating power, which he had formerly overlooked. The conclusion which the Psalmist draws respecting the *wisdom* displayed throughout all the works of God, plainly intimates, that he had made the different parts of nature the subject of minute examination and of deep reflection; otherwise he could not have rationally deduced his conclusion, or felt those emotions which filled his mind with the pious raptures so beautifully expressed in that hymn of praise to the Creator of the world.

We have therefore reason to believe, from these and other instances, that pious men, "in the days of old," were much more accustomed than modern Christians to contemplate and admire the visible works of the Lord; and it is surely much to be regretted, that we, who enjoy so many superior means of information, and who have access to the brilliant discoveries of later and more en-

lightened times, should manifest so much disregard to "the works of Jehovah, and the operations of his hands." To enable the common mass of Christians to enter into the spirit of this delightful study and *Christian duty* should therefore be one object of those periodical and other religious works which are put into their hands; so that they may be enabled, with vigour and intelligence, to form the pious resolution of Asaph, "I will meditate on all thy works, O Lord! and talk of thy doings." "I will utter abundantly the memory of thy great goodness, and tell of all thy wondrous works."[1]

Geography.

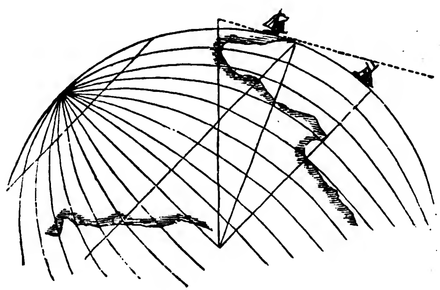
The next department of knowledge I shall notice is the science of Geography.

The object of this science is, to describe the world we inhabit, in reference to the continents, islands, mountains, oceans, seas, rivers, empires, and kingdoms with which it is diversified, together with the manners, customs, and religion of the different tribes which people its surface.

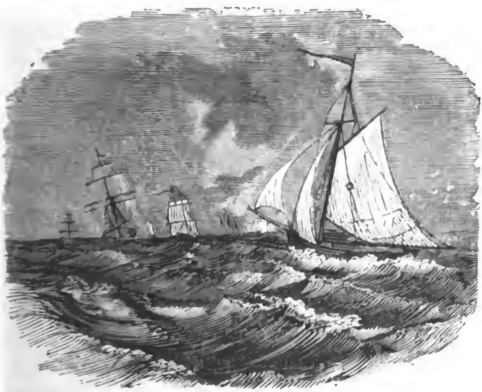
In order to form an accurate conception of the relative positions of objects on the surface of the earth, and to enter, with intelligence, on the study of this subject, it is requisite, first of all, to have an accurate idea of its *figure and magnitude.* For a long series of ages, it was supposed, by the bulk of mankind, that the surface of the earth was nearly a plane, indefinitely extended, and bounded on all sides by the sky. Lactantius, and several of the fathers of the Christian Church, strenuously argued, that the earth was extended infinitely downwards, and established upon several foundations. The ancient philosopher Heraclitus is said to have believed that the earth was of the shape of a skiff or canoe, very much hollowed; and the philosopher Leucippus supposed it to be of the form of a cylinder or a drum. It is only within the period of the last 300 years that the true figure of the earth has been accurately ascertained. This figure is now found to be that of an oblate spheriod, nearly approaching to the shape of a globe or sphere. To have asserted this opinion several ages ago would

have been considered as a heresy in religion, and would have subjected its abettors to the anathemas of the Church, and even to the peril of their lives. Historians inform us, that the learned Spigelius, bishop of Upsal in Sweden, suffered martyrdom at the stake, in defence of the doctrine of the *Antipodes;* and we know that, for asserting the motion of the earth, the celebrated philosopher Galileo was immured in a dungeon, and condemned, by an assembly of cardinals, to all the horrors of perpetual imprisonment. The doctrine he maintained, and which is now universally received by every one acquainted with the subject, was declared by these arrogant ecclesiastics to be "a proposition absurd in its very nature, false in philosophy, heretical in religion, and contrary to the holy Scriptures." Such are some of the horrible and pernicious consequences which flow from ignorance of the phenomena of nature, and of those laws by which the Almighty governs the universe he has formed; and which prove it to be a Christian duty for every rational being to study the order and economy of the visible world.

That the earth is nearly of a globular figure is proved by the following considerations:— 1. When we stand on the sea-shore, while the sea is perfectly calm, we perceive that the surface of the water is not quite plane, but convex or rounded: and if we are on one side of an arm of the sea, as the frith of Forth, and, with our eyes near the water, look toward the opposite coast, we shall plainly see the water elevated between our eyes and the opposite shore, so as to prevent our seeing the land near the edge of the water. The same experiment may be made on any portion of still water, of a mile or two in extent, when its convexity will be perceived by the eye. A little boat, for instance, may be perceived by a man who is any height above the water, but if he stoops down, and lays his eye near the surface, he will find that the fluid



appears to rise, and intercept the view of the boat. 2. If we take our station on the sea-shore, and view the ships leaving the coast, in any direction — as they retire from our view, we may perceive the masts and rigging of the vessels when the hulls are out of sight, and, as it were, sunk in the water. On the other hand, when a ship is approaching the shore, the first part of her that is seen is the topmast; as she approaches nearer, the sails become visible, and, last of all, the hull comes gradually into view.[1] The reason of such appearances obviously is, that the round or convex surface of the water interposes between our eye and the body of the ship, when she has reached a certain distance, while, at the same time, the sails and topmast, from their great elevation, may be still in view. To the same cause it is owing, that the higher the eye is placed, the more extensive is the prospect; and hence it is common for sailors to climb to the top of masts, in order to discover land or ships at a distance. The contrary of all this would take place, if the earth and waters were an extended plane. When a ship came within view, the hull would first make its appearance, being the largest object, next the sails, and last of all the topmast. These considerations, which hold true in all parts of the world, prove to a certainty, that the mass of the ocean is of a globular form; and if the ocean be a portion of a sphere, it follows, that



SHIPS SEEN BEYOND THE HORIZON.

[1] In order to make such observations to advantage, the observer's eye should be, as near as possible, on a level with the sea, and he should use a telescope to enable him to perceive more distinctly the upper parts of the vessel.

the *land* also is of the same general figure; for no portion of the earth's surface is elevated above four or five miles above the level of the ocean. 3. That the earth is round from north to south appears from the following circumstances:—When we travel a considerable distance from north to south, or from south to north, a number of new stars successively appear in the heavens, in the quarter to which we are advancing, and many of those in the opposite quarter gradually disappear, which would not happen if the earth were a plane in that direction. 4. That the earth is round from east to west appears from actual experiment; for many navigators, by sailing in a westerly direction, have gone round it, from east to west; and were it not for the frozen seas within the polar regions, which interrupt navigation in those directions, it would, long ere now, have been circumnavigated from north to south. 5. All these proofs are confirmed and illustrated by eclipses of the moon, which present an *ocular demonstration* of the earth's rotundity. An eclipse of the moon is caused by the intervention of the body of the earth between the sun and the moon; in which case, the shadow of the earth falls upon the moon. This shadow is found in all cases, and in every position of the earth, to be of a *circular* figure; which incontrovertibly proves that the whole mass of land and water of which the earth is composed is nearly of a globular form. The mountains and vales which diversify its surface detract little or nothing from its globular shape; for they bear no more proportion to its whole bulk than a few grains of sand to a common terrestrial globe; the highest mountains on its surface being little more than the 2000th part of its diameter. Some of the mountains on the surface of the moon are higher than those on the earth, and yet that body appears, both to the naked eye and through telescopes of a spherical figure.

To some readers, the discovery of the true figure of the earth may appear as a matter of very trivial importance in religion. I hesitate not, however, to affirm, that it constitutes a most important fact in the history of divine providence. Had not this discovery been made, it is probable that the vast continent of America might yet have remained undiscovered; for Columbus, who first discovered that new world, had learned, contrary to the general opinion of those times, that the earth was of a spherical figure; and, from the maps then existing, he began to conjecture that the

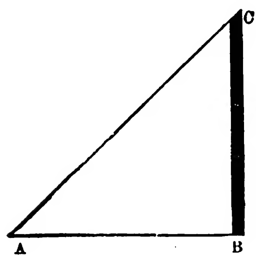
nearest way of sailing to the East Indies would be to sail westward. And although he missed the object of his research, he was the means of laying open to view a vast and unknown region of the earth, destined, in due time, to receive from the eastern world the blessings of knowledge, civilization, and religion. On the knowledge of the spherical figure of the earth the art of navigation in a great measure depends; and all the voyages of discovery which have been made in later years were undertaken in consequence of the knowledge of this fact. Had mankind remained unacquainted with this discovery, the circumnavigation of the globe would never have been attempted; vast portions of the habitable world would have remained unknown and unexplored; no regular intercourse would have been maintained between the various tribes of the human race; and consequently, the blessings of Divine Revelation could never have been communicated to the greater part of the Gentile world. Besides, the knowledge of the true figure and magnitude of our sublunary world forms the groundwork of all the sublime discoveries which have hitherto been made in the regions of the firmament. For its diameter forms the *base line* of those triangles by which the distances and magnitude of the celestial globes have been determined,[1] without a knowledge of the extent of which, the important results which have been deduced respecting the system of the universe, could not have been ascertained, and consequently, our views of the grandeur and omnipotence of the Deity, and of the magnificence and extent of his dominions, must have been much more circumscribed than they now are. Such is the intimate connection that subsists between every part of the chain of Divine dispensations, that if any one link had been either broken or dissolved, the state of things, in the moral and intellectual world, would have been very different from what it now is; and the plans of Providence, for accomplishing

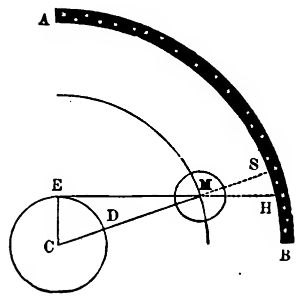
[1] In order that the general reader may understand what is meant by "the diameter of the earth forming the *base-line* of those triangles by which the distances, etc. of the heavenly bodies are measured," it may not be unnecessary to state the following explanations.

In any triangle, as A B C, if the length of the side A B be known, and likewise the quantity of the angles at A and B, or the number of degrees or minutes they subtend, be ascertained, we can find the length of the sides A C and A B. If A B represent a horizontal plane, 100 feet in extent, and C B a tower whose height we wish to determine, and if, with a quadrant, we find the angle at A, or C A B, to be 43 degrees; then by an easy

the renovation and improvement of mankind, would have been either partially or totally frustrated.

trigonometrical process—Radius : is to the tangent of A, 43° : : as the side A B, 100 feet : is to the height of the tower C B, which, in this case, will be found to be 93¼ feet.





It is on this general principle that the distances and magnitudes of the celestial bodies are determined. But, in all cases where we wish to ascertain the dimensions of the different parts of a triangle—*one side*, at least, must be given, along with two angles, otherwise the length of the different sides of the triangle cannot be determined.—Now, in measuring the distance of a heavenly body, such as the Moon, the *diameter* or *semidiameter* of the earth is the *known side* of the triangle by which such a distance is to be found. In the above, let E C represent the Earth, M the Moon, and A B a portion of the starry firmament. If a spectator on the earth's surface at E view the moon in the horizon, it will appear in the line E M, among the stars at H. But, if viewed from the centre of the earth at C or from the surface at D, it will appear in the line C D M, among the stars at S. The difference of position in which the moon is seen, as viewed from the surface of the earth E, and the centre C, is called the moon's horizontal parallax, or the arc S H, which is subtended by the angle S M H, which is equal to the angle E M C. In determining the distance of the moon, therefore, we must first find, by observation, the horizontal parallax, or, in other words, the angle E M C; and the side E C, or the semidiameter of the earth being known to be about 4000 miles in extent, forms the *base line* of the triangle E M C, and hence the other sides of the triangle E M and C M, or the distance of the moon from the earth, can be found by an easy calculation.

From what has been now stated, it will appear that, were we ignorant of the figure and magnitude of the earth, we could not ascertain the distance of the moon or any other celestial body. In the above explanation I have merely stated the *principle* on which astronomers proceed in measuring

With regard to the *magnitude* of the earth—I have already stated the mode by which we may acquire the most accurate and comprehensive conception of this particular, in the course of the illustrations which were given of the Omnipotence of Deity—(pp. 39-44). It is necessary here only to remark that, according to the latest computations, the diameter of the earth is about 7930 miles, and its circumference 24,912 miles; and consequently, the whole surface of the land and water it contains comprehends an area of 197,552,160 miles. The proportion of land and water on its surface cannot be very accurately ascertained; but it is quite evident, from an inspection of a map of the world, that the water occupies at least two-thirds of its surface, and of course the land cannot occupy more than one third. Supposing it to be only one-fourth of the earth's surface, it will contain 49,388,040 square miles, which is considerably more than what is stated in most of our late systems of Geography; in some of which the extent of the land is rated at 39,000,000, and in others so low as 30,000,000 of square miles—the former of which statements being less than a fifth, and the latter less than a sixth of the surface of the globe. But it is quite obvious that the extent of the land cannot be less than a fourth of the area of the globe, and must, therefore, comprehend at least about 50,000,000 of square miles. And if a large arctic continent, exist around the North Pole, as some French Philosophers infer, from Captain Parry's discoveries—the quantity of land on the terraqueous globe will be much greater than what has been now stated.

General Divisions of the Earth.—The surface of the earth is divided, from north to south, by two bands of earth, and two of water. The first band of earth is the ancient or Eastern Continent, comprehending Europe, Asia, and Africa; the greatest length of which is found to be in a line beginning on the east point of the northern part of Tartary, and extending from thence to the cape of Good Hope, which measures about 10,000 miles in a direction nearly from north-east to south-west; but if measured according to the meridians, or from north to south, it extends only 7500 miles, from the northernmost cape in Lapland to the cape of Good Hope.

the distances of bodies in the heavens, without descending into details. For a more particular explanation and illustration of this subject, the reader is referred to the author's work entitled 'Celestial Scenery,' chap. vii, where the subject is pretty fully and popularly treated.

This vast body of land contains about 36,000,000 of square miles, forming nearly a fifth of the whole surface of the globe. The other band of earth is what is commonly called the New World, which comprehends North and South America. Its greatest length lies in a line beginning at the mouth of the river Plata, passing through the island of Jamaica, and terminating beyond Hudson's Bay; and it measures about 8000 miles. This body of land contains about 14,000,000 of square miles, or somewhat more than a third of the Old Continent.

It may not be improper here to remark, that the two lines now mentioned, which measure the greatest length of the two continents, divide them into two equal parts, so that an equal portion of land lies on each side of these lines, and that each of the lines has an inclination of about 30 degrees to the equator, but in opposite directions; that of the old continent extending from the north-east to the south-west; and that of the new continent, from the north-west to the south-east; and that they both terminate at the same degree of northern and southern latitude. It may also be noticed, that the old and new continents are almost opposite to each other, and that the old is more extensive to the north of the equator, and the new more extensive to the south. The centre of the old continent is in the 17th degree of north latitude, and the centre of the new in the 17th degree of south latitude; so that they seem to be made to counterbalance each other, in order to preserve the equability of the diurnal rotation of the earth. There is also a singular connection between the two continents, namely, that if they were divided into two parts, all four would be surrounded by the sea, were it not for the two small necks of land called the isthmuses of Suez and Panama.[1]

Between the two continents now mentioned lie two immense bands of water, termed the Pacific and the Atlantic oceans, whose greatest length is likewise in a direction from north to south.

Besides the two bands of earth to which I have adverted, many extensive portions of land are dispersed through the ocean, which covers the remaining part of the earth's surface; particularly the extensive regions of Australasia which occupy a space nearly as large as the whole of Europe, and the Arctic continent, which probably exists within the North Polar regions, and which some

[1] See Buffon's Natural History, vol. i.

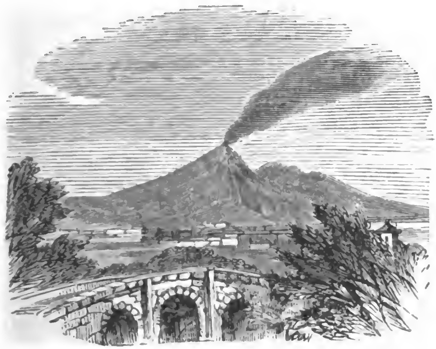
French writers propose to designate by the name of *Boreasia*, is, in all probability, of equal extent. There are also the extensive islands of New Guinea, Borneo, Madagascar, Sumatra, Japan, Great Britain, New Zealand, Ceylon, Iceland, Cuba, Java, and thousands of others, of different dimensions, scattered through the Pacific, the Indian, and the Atlantic oceans, and which form a very considerable portion of the habitable regions of the globe. To these must be added the newly-discovered island, called Euderby's Land, in the South Arctic ocean. This island is now used as a whale fishing station, and is by many supposed to belong to the Southern Continent so long imagined by Philosophers as necessary to balance the mass of land in the north temperate zone.

General Features of the Earth's Surface.—In taking a general survey of the external features of the earth, the most prominent objects that strike the eye are those huge elevations which rise above the level of its general surface, termed *Hills* and *Mountains*. These are distributed in various forms and sizes, through every portion of the continents and islands; and running into immense chains, form a sort of connecting band to the other portions of the earth's surface. The largest mountains are generally formed into immense chains, which extend, in nearly the same direction, for several hundreds and even thousands of miles. It has been observed, by some philosophers, that the most lofty mountains form two immense ridges or belts, which with some interruptions, extend around the whole globe in nearly the same direction. One of these ridges lies between the 45th and 55th degrees of north latitude. Beginning on the western shores of France and Spain, it extends eastward, including the Alps and the Pyrenees, in Europe, the Uralian and Altaic mountains, in Asia—extending from thence to the shores of Kamtschatka, and, after a short interruption from the sea, they rise again on the western coast of America, and terminate at Canada, near the eastern shore. It is supposed that the chain is continued completely round the globe, through the space that is covered by the Atlantic ocean, and that the Azores, and other islands in that direction, are the only summits that are visible till we come to the British isles. The other ridge runs along the southern hemisphere, between the 20th and 30th degrees of south latitude, of which detached portions are found in the mountains

of Tucuman and of Paraguay, in South America; of Monomotapa and Caffraria, in Africa; in Australia, New Caledonia, the New Hebrides, the Friendly, the Society, and other islands in the Pacific ocean. From these ridges flow a variety of ramifications, in both hemispheres, towards the Equator and the Poles, which altogether presents the magnificent scenery, diversifying and enlivening the surface of our globe.

The highest mountains in the world, according to some late accounts published in the "Transactions of the Asiatic Society," are the *Himalaya* chain, north of Bengal, on the borders of Tibet. The highest mountain in this range is stated to be about 27,000 feet, or a little more than five miles in perpendicular height, and is visible at the distance of 230 miles. Nineteen different mountains in this chain are stated to be above four miles in perpendicular elevation. Next to the Himalayas are the Andes, in South America, which extend more than 4000 miles in length, from the province of Quito to the straits of Magellan. The highest summit of the Andes is Chimborazo, which is said to be 20,600 feet, or nearly four miles, above the level of the sea. The highest mountains in Europe are the Alps, which run through Switzerland and the north of Italy,—the Pyrenees, which separate France from Spain, and the Dofrafeld, which divide Norway from Sweden. The highest peaks of the Alps are—Mont Blanc, in Savoy, 15,668 feet high; the ascent of which has several times been made within the last few years. Mount Rosa, in Savoy, near the confines of Switzerland, 15,527 feet high; Finsteraarhom, in Switzerland, 14,325 feet high; Pelvoux de Vallouise, on the French territory, 14,044 feet high; and the Jungfrau, or Virgin, 13,730 feet high. The most elevated ridges in Asia are mounts Taurus, Imaus, Caucasus, Ararat, the Uralian, the Altaian, and the mountains of Japan,—in Africa, Mount Atlas, and the mountains of the moon. Some of the mountains in these ranges are found to contain immense caverns or perforations, of more than two miles in circumference, reaching from their summits to an immeasurable depth in the bowels of the earth. From these dreadful openings are frequently thrown up, to an immense height, torrents of fire and smoke, rivers of melted metals, clouds of ashes and cinders, and sometimes red-hot stones and enormous rocks, to the distance of several miles accompanied with thunders, lightnings, darkness,

and horrid subterraneous sounds—producing the most terrible devastations through all the surrounding districts. The most noted mountains of this kind in Europe are mount Hecla, in Iceland; Etna, in Sicily; and Vesuvius, near the city of Naples, in Italy. Several eruptions of this volcano have took place in 1854 and 1855, destroying vineyards, overwhelming houses, and injuring much valuable property. Numbers of volcanoes are also found in South America, in Africa, in the islands of the Indian ocean, and in the empire of Japan.[1]



MOUNT VESUVIUS.

We who live in Great Britain, where the highest mountain is little more than three quarters of a mile in perpendicular elevation, can form no adequate idea of the magnificence and awful sublimity of the mountain scenery in some of the countries now mentioned; especially when the volcano is belching forth its flames with a raging noise, and spreading terror and desolation around its base. From the tops of the lofty ridges of the Andes, the most grand and novel scenes sometimes burst upon the eye of the astonished traveller. He beholds the upper surface of the clouds far below him covering the subjacent plain, and surrounding, like a vast sea, the foot of the mountain; while the place on which he stands appears like an island in the midst of the ocean. He sees the lightnings issuing from the clouds, and hears the noise of the tempest and the thunders rolling far beneath his feet, while all is serene around him, and the blue vault of heaven appears without a cloud. At other times he contemplates the most sublime and extensive prospects—mountains ranged around him, covered with

[1] A more particular description of the phenomena of these terrific objects will be found in chap iv, sect. 2.

eternal snows, and surrounding like a vast amphitheatre the plains below—rivers winding from their sources towards the ocean—cataracts dashing headlong over tremendous cliffs—enormous rocks detached from their bases, and rolling down the declivity of the mountains with a noise louder than thunder—frightful precipices impending over his head—unfathomable caverns yawning from below—and the distant volcano sending forth its bellowings, with its top enveloped in fire and smoke. Those who have studied nature on a grand scale have always been struck with admiration and astonishment at the sublime and awful exhibition of wonders which mountainous regions exhibit; and perhaps there is no *terrestrial* scene which presents, at one view, so many objects of overpowering magnitude and grandeur, and which inspires the mind with so impressive an idea of the power of that Almighty Being, who "weigheth the mountains in scales and taketh up the isles as a very little thing."

THE OCEAN.—The ocean surrounds the earth on all sides, and penetrates into the interior parts of different countries, sometimes by large openings, and frequently by small straits. Recent discoveries in the Polar Regions, made by Captain M'Clure, in his search for the ill-fated Sir John Franklin, have established the fact of a great Polar Sea in the Arctic circle, and consequently realizing the truth of the geographical axiom that the earth is surrounded by the ocean. Could the eye take in this immense sheet of waters at one view, it would appear the most august object under the whole heavens. It occupies a space on the surface of the globe at least three times greater than that which is occupied by the land; comprehending an extent of 148,000,000 of square miles. Though the ocean, strictly speaking, is but *one* immense body of waters, extending in different directions, yet different names have been appropriated to different portions of its surface. That portion of its waters which rolls between the western coast of America, and the eastern shores of Asia, is called the *Pacific* ocean; and that portion which separates Europe and Africa from America, the *Atlantic* ocean. Other portions are termed the *Northern*, *Southern*, and *Indian* oceans. When its waters penetrate into the land, they form what are called gulfs, and mediterranean (midland) seas. But without following it through all its windings and divisions, I shall simply state a few general facts.

With regard to the DEPTH of this body of water, no certain conclusions have yet been formed. Beyond a certain depth it has hitherto been found unfathomable. We know, in general, that the depth of the sea increases gradually as we leave the shore; but we have reason to believe that this increase of depth continues only to a certain distance. The numerous islands scattered every where through the ocean demonstrate, that the bottom of the waters, so far from uniformly sinking, sometimes rises into lofty mountains. It is highly probable, that the depth of the sea is somewhat in proportion to the elevation of the land; for there is some reason to conclude, that the present bed of the ocean formed the inhabited part of the ancient world previous to the general Deluge, and that we are now occupying the bed of the former ocean; and if so, its greatest depth will not exceed four or five miles; for there is no mountain that rises higher above the level of the sea. But the sea has never been actually sounded to a greater depth than one mile and sixty-six feet. Along the coast its depth has always been found proportioned to the height of the shore; where the coast is high and mountainous the sea that washes it is deep; but where the coast is low the water is shallow. To calculate the *quantity of water* it contains we must therefore suppose a medium depth. If we reckon its average depth at two miles, it will contain 296,000,000 of cubical miles of water. We shall have a more specific idea of this enormous mass of water, if we consider, that it is sufficient to cover the whole globe, to the height of more than 8000 feet; and if this water were reduced to one spherical mass, it would form a globe of more than 8000 miles in diameter.

With regard to its BOTTOM—As the sea covers so great a portion of the globe, we should no doubt, by exploring its interior recesses, discover a vast number of interesting objects. So far as the bed of the ocean has been explored, it is found to bear a great resemblance to the surface of the dry land; being, like it, full of plains, caverns, rocks, and mountains, some of which are abrupt and almost perpendicular, while others rise with a gentle acclivity, and sometimes tour above the water, and form islands. The materials, too, which compose the bottom of the sea are the same which form the bases of the dry land. It also resembles the land in another remarkable particular;—many fresh springs, and even rivers, rise out of it; an instance of which occurs near Goa, on the western coast of Hindostan, and in the Mediterranean sea, not far

from Marseilles. The sea sometimes assumes *different colours.* The materials which compose its bottom cause it to reflect different hues in different places; and its appearance is also affected by the winds and by the sun, while the clouds that pass over it communicate all their varied and fleeting colours. When the sun shines it is green; when he gleams through a fog it is yellow; near the poles it is almost black; while in the torrid zone its colour is often brown; and, on certain occasions, it assumes a luminous appearance, as if sparkling with fire.

The ocean has *three kinds of motions.* The first is that undulation which is produced by the wind, and which is entirely confined to its surface. It has been ascertained that this motion can be destroyed, and its surface rendered smooth, by throwing oil upon its waves, hence the truth of the scriptural phrase—"throwing oil upon the troubled waters." The second motion is that continual tendency which the whole water in the sea has towards the west, which is greater near the equator than towards the poles. It begins on the west side of America, where it is moderate; but as the waters advance westward, their motion is accelerated; and, after having traversed the globe, they return, and strike with great violence on the *eastern* shore of South America. Being stopped by that continent, they rush, with impetuosity, into the Gulf of Mexico, thence they proceed along the coast of North America, till they come to the south side of the great bank of Newfoundland, when they turn off and run down through the Western isles. This motion is most probably owing to the diurnal revolution of the earth on its axis, which is in a direction contrary to the motion of the sea. The third

THE SUN AND MOON IN CONJUNCTION PRODUCING SPRING TIDES.

motion of the sea is the *tide,* which is a regular swell of the ocean every twelve-and-a-half hours. This motion is now ascertained to

be owing to the attractive influence of the moon, and also partly to that of the sun. There is always a flux and reflux at the same time, in two parts of the globe, and these are opposite to each other; so that when our Antipodes have high water we have the same. When the attractive powers of the sun and moon act in the same direction, which happens at the time of new and full

THE SUN AND MOON IN OPPOSITION CAUSING NEAP TIDES.

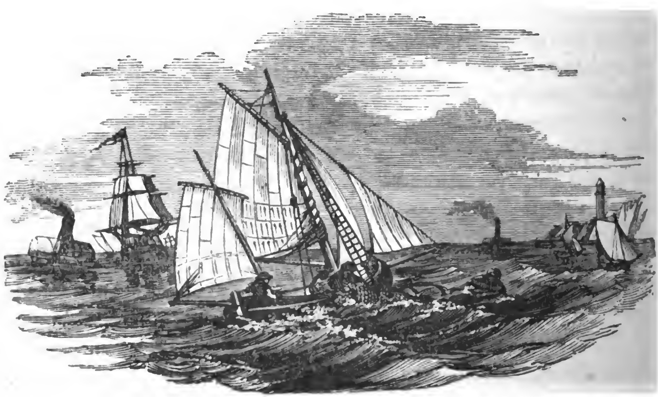
moon, we have the highest or *spring tides;* but when their attraction is opposed to each other, which happens at the quarters, we have the lowest or *neap tides.*

Such is the ocean, a most stupendous scene of Omnipotence, which forms the most magnificent feature of the globe we inhabit. When we stand on the sea-shore, and cast our eyes over the expanse of its waters, till the sky and the waves seem to mingle, all that the eye can take in at *one* survey is but an inconsiderable *speck,* less than the 100,000th part of the whole of this vast abyss. If every drop of water can be divided into 26,000,000 of distinct parts, as some philosophers have demonstrated,[1] what an immense assemblage of watery particles must be contained in the unfathomable caverns of the ocean! Here the powers of calculation are completely set at defiance; and an image of infinity, immensity, and endless duration, is presented to the mind. This mighty expanse of waters is the grand reservoir of Nature, and the source of evaporation, which enriches the earth with fertility and verdure. Every cloud which floats in the atmosphere, and every fountain, and rivulet, and flowing stream, are indebted to this inexhaustible

1 The demonstration of this proposition may be seen in Nieuwentyt's Religious Philosopher, vol. iii., p. 852.

source for those watery treasures which they distribute through every region of the land. In fine, whether we consider the ocean as rearing its tremendous billows in the midst of the tempest, or as stretched out into a smooth expanse—whether we consider its immeasurable extent, its mighty movements, or the innumerable beings which glide through its rolling waves—we cannot but be struck with astonishment at the grandeur of that Omnipotent Being who holds its waters in the "hollow of his hand," and who has said to its foaming surges, "Hitherto shalt thou come, and no farther; and here shall thy proud waves be stayed."

Rivers—The next feature of the earth's surface which may be noticed is the rivers with which it is indented in every direction. These are exceedingly numerous, and seem to form as essential a part in the constitution of our globe as the mountains from which they flow, and as the ocean to which they direct their course. It is reckoned, that in the old continent there are only about 430 rivers which fall directly into the ocean, or into the Mediterranean and the Black seas; but in the new continent there are only about 145 rivers known which fall directly into the sea. In this enumeration, however, only the great rivers are included, such as the



SCENE ON THE RIVER THAMES.

Thames, the Danube, the Wolga, and the Rhone. Besides these there are many thousands of streams of smaller dimensions, which

rising from the mountains, wind in every direction, till they fall into the large rivers, or are carried into the ocean. The largest rivers in Europe are—the Wolga, which, rising in the northern parts of Russia, runs a course of 1700 miles, till it falls into the Caspian sea—the Danube, whose course is 1300 miles, from the mountains in Switzerland to the Black sea—and the Don, which runs a course of 1200 miles. The greatest rivers in Asia are—the Hoangho, in China, whose course is 2400 miles—the Boorhampooter, the Euphrates, and Ganges. The longest river in Africa is the Nile, the course of which is estimated at 2000 miles. In the continent of America, the rivers appear to be formed on the grandest scale, both as to the length of their course and the vast body of waters which they pour into the ocean. The Amazon, the largest river in the world, runs a course of above 3000 miles across the continent of South America, till it falls into the Atlantic ocean, where it discharges a body of waters 150 miles in breadth. Next to this is the river St. Lawrence, which is more than 2400 miles from its mouth through the lake of Ontario to the lake Alempigo and the Assiniboils; and the rivers La Plata and Mississippi, each of whose course is not less than 2000 miles.

When we consider the number and the magnitude of these majestic streams, it is evident, that an enormous mass of water is continually pouring into the ocean from every direction. From observations which have been made on the river Po, which runs through Lombardy, and waters a tract of land 380 miles long and 120 broad, it is found, that it moves at the rate of four miles an hour, 1000 feet broad and ten feet in depth, and consequently, supplies the sea with 5,068,000,000 of cubical feet of water in a day, or a cubical mile in twenty-nine days. On the supposition that the quantity of water which the sea receives from the great rivers in all countries, is proportional to the extent and surface of these countries, it will follow, that the quantity of water carried to the sea by all the other rivers on the globe, is 1083 times greater than that furnished by the Po, (supposing the land, as formerly stated, to contain about 49,000,000 of square miles,) and will supply the ocean with 13,630 cubical miles of water in a year. Now reckoning the ocean, as formerly, to contain 296,000,000 of cubical miles of water, this last number divided by the former will give a quotient of 21,716.

Hence it appears, that, were the ocean completely drained of its waters, it would require more than 20,000 years before its caverns

could be again completely filled by all the rivers in the world running into it at their present rate.[1]

Here two questions will naturally occur—Whence do the rivers receive so constant a supply of water? and, Why has not the ocean long ago overflowed the world, since so prodigious a mass of water is continually flowing into its abyss? This was a difficulty which long puzzled philosophers; but it is now satisfactorily solved, from a consideration of the effects of evaporation. By the heat of the sun, the particles of water are drawn up into the atmosphere, from the surface of the ocean, and float in the air in the form of clouds, or vapour. These vapours are carried, by the winds, over the surface of the land, and are again condensed into water on the tops and sides of the mountains, which, gliding down into their crevices and caverns, at length break out into springs, a number of which, meeting in one common valley, become a river; and many of these united together at length form such streams as the Tay, the Thames, the Danube, and the Rhine. That evaporation is sufficient to account for this effect has been demonstrated by many experiments and calculations. It is found, that from the surface of the Mediterranean sea, which contains 762,000 square miles, there are drawn up into the air every day by evaporation, 5,280,000,000 of tons of water, while the rivers which flow into it yield only 1,827,000,000 of tons in the same time; so that there is raised in vapour from the Mediterranean nearly three times the quantity of water which is poured into it by all its rivers. One-third of this falls into the sea before it reaches the land; another part falls on the low lands, for the nourishment of plants; and the other third part is quite sufficient to supply the sources of all the rivers which run into the sea. This is in full conformity to what was long ago stated by an inspired Naturalist; "All the rivers run into the sea, and yet the sea is not full; unto the place from whence the rivers came, thither do they return again;" but before they regain their former place they make a circuit over our heads through the regions of the atmosphere.

Such are the varied movements and transformations which are

[1] Buffon makes this result to be 812 years, in which he is followed by Goldsmith, and more subsequent writers; but he proceeds on the false assumption, that the ocean covers only half the surface of the globe and that it contains only 85,000,000 of square miles, and he estimates the average depth of the ocean to be only 440 yards, or one fourth of a mile.

incessantly going on in the rivers, the ocean, and the atmosphere, in order to preserve the balance of nature, and to supply the necessities of the animal and vegetable tribes; all under the agency and direction of Him who "formed the sea and the dry land," and who has arranged all things in number, weight, and measure, to subserve the purposes of his will.

Rivers serve many important purposes in the economy of our globe. They carry off the redundant waters which fall in rains, or which ooze from the springs, which might otherwise settle into stagnant pools; they supply to the seas the loss of waters occasioned by their daily evaporation; they cool the air, and give it a gentle circulation; they fertilize the countries through which they flow; their waters afford a wholesome drink, and the fishes they contain a delicious food for the nourishment of man; they facilitate commerce, by conveying the productions of nature and art from the inland countries to the sea; they form mechanical powers for driving machinery of different kinds; they enliven and diversify the scenery of the countries through which they pass; and the cataracts which they frequently form among the mountains present us with scenes the most picturesque and sublime; so that every part of the constitution of nature is rendered subservient both to utility and to pleasure.

Lakes.—Under this term are comprehended those large collections of inland waters which are to be found in various parts of the world. Lakes arise either from the drainage of the surrounding country into a natural level or basin, or are the result of subterranean springs. Sometimes they form the inland terminations of great rivers, and in others, their rise or commencement, as in North America, and in some few cases they seem to possess no inlet or outlet for their waters. They are both salt and fresh. They exercise great influence over the commerce of the countries in which they exist, and when joined to each other, or to rivers of the ocean, afford great facilities for inland navigation. Lake Superior, the largest of the North American lakes, is about 400 miles long by 160 miles wide, and is more than 600 feet above the level of the Atlantic. It is said that a great inland lake exists in the interior of Africa, but no certain accounts of it have been received.

Cataracts.—A cataract is a precipice in the channel of a river, caused by rocks or other obstacles interrupting the course of the

stream, from whence the water falls with a great noise and impetuosity. The law of gravitation produces a vast variety of scenery in the system of nature. It rolls the moon round the earth, the planets round the sun, and connects together the different systems of the universe. In relation to our globe, it causes the mountains to rest on a solid basis, it produces the descent of rains and dews, it retains the inhabitants of the earth to its surface, it causes the rivers to flow into the seas, and confines the ocean to its appointed channels. It is the same power which produces the roaring cataract, when a large river meets with a perpendicular precipice in its course, and dashes its waters with fury into the plains below—which gives rise to some of the most sublime scenery in nature. This is one circumstance out of many others which shows what a variety of scenes and effects may be produced by the operation of a single principle in the hands of the Creator.

In order to give the reader some idea of this feature of our globe, I shall present a few brief sketches of some of the most remarkable cataracts in different countries. I shall commence with

THE CATARACTS OF THE NILE.—This river, through its long range of 2000 miles, in winding through abrupt and precipitous regions, exhibits to view a variety of striking cataracts, about twelve of which occur before it reaches the level of Egypt. The following is a description of the *great Cataract* of the Nile as given by Mr. Bruce, the celebrated African traveller, who visited the scene.—"At the distance of half a mile beneath the cataract the river is confined between two rocks, over which a strong bridge of a single arch has been thrown, and runs into a deep trough with great roaring and impetuous velocity. On ascending, the cataract presents itself amid groves of beautiful trees, and exhibits a most sublime and stupendous sight, such as ages, added to the greatest length of human life, could not efface from my memory. It struck me with a kind of stupor, and a total oblivion of where I was, as well as of every sublunary concern. At the time of this visit the river had been considerably increased by rains, and fell in one sheet of water, above half an English mile in breadth, and to the depth of at least forty feet, with a force and noise that were truly terrific, and which for a time stunned me and made me giddy. A thick fume or haze covered the fall in every part, and hung over the course of the stream both above and below, marking its track, although the waters were not seen. The river, although much

swollen, preserved its natural clearness, and fell partly into a deep pool or basin in the solid rock, and partly in twenty different eddies to the very foot of the precipice. In falling, a portion of the stream appeared to run back with great fury on the rock, as well as forward on the line of its course, raising waves or violent ebullitions, which chafed against each other."

Another celebrated cataract, or cascade, is that of *Tivoli*, in Italy, on the river Teverone, which falls into the Tiber. The scenery of this cataract is said to be "wild, lovely, and tenderly sublime," and, if what Eustace and Byron have said of these falls be correct, they must be numbered among the most towering scenes which nature presents to a traveller's eye. In the district of these falls, it would appear, that the fairest scenes and boldest glories meet the vision of the beholder. The first fall is viewed from a bridge thrown over a narrow channel a little below it; there all the writhings and tossings of the tempestuous water flash brightly on the eye. It is seen rushing from a chasm above in maddening fury, and boiling as fiercely as man's furious passions, as it precipitates itself into the caverns below, passing onward by a winding path into a romantic but narrow dell, through which the river floats and flows after the cascade—The second fall is seen in two immense sheets—the water tumbles, and the mountains are shaken by the thunder of its fall—the waters war and whirl and hiss in one continued voice of storm. To hear—to see—to feel the scene must be to condense in a day the poetry of an age; flashing waters rushing from an headlong height, darkening the eye with their torrent of grandeur, and dizzying the ear with their vast and awful tones. "If one could suppose," says a writer, "such a catastrophe as the dissolution of an element of nature, the most frenzied imagination could not conjecture a more magnificent funeral than the all-splendid yet solemnly grand scenes of Tivoli, where every wind is thunder, and every wave is lightning." The scenery around these falls is likewise said to harmonize with their sublimity: Rocky eminences—craggy steeps connected with the falls—the grotto of Neptune, dark, impalpable, and gloomy—black yawning gulfs, and similar objects, add to the romantic interest of the scene. At the same time a thousand classical associations present themselves. Near the bottom of an eminence on which Tivoli stands are the ruins of the vast and magnificent villa built by the Emperor Adrian. Other illustrious Romans had likewise their villas in this locality, as Julius Cæsar, Augustus

the poets Catullus and Propertius; and here Horace is supposed to have composed the greater part of his works. Zenobia, too, the princess of the East, had her residence given her here by Aurelian, and here she died, A. D. 280. Another great attraction is the temple of the Sybil, which is fast falling to ruin, and desolation takes her dwelling in the midst of its courts and halls. These and other associations render the scenery of these falls highly interesting to the classical and philosophic traveller.

The falls of *Terni* or *Velini* are at no great distance from Tivoli. This fall is described as a *tremendous cascade.* Its appearance is said to be even more wildly majestic than Tivoli. The river rushes among the rocks, and precipitates itself in a series of falls over a perpendicular precipice, losing itself in thunder over the foam and spray of the gulf below. The first fall takes place where the stream is yet confined among the rocks of the channel, which is then much broken, and has an elevation of forty or fifty feet. The second fall is a descent of above 500 feet; it afterwards strikes against a rock, and rushes down repeated falls, so close as to form almost one continued sheet of foam for 240 feet into the river Nar; so that the whole descent is about 800 feet.

But, of all the cataracts in the world, that of *Niagara* in North America is considered as the greatest and the most astonishing. This amazing fall of water is made by the river St. Lawrence in its passage from Lake Erie into Lake Ontario. This river is the largest in North America, and the whole of its waters are here poured down by a fall of 150 feet perpendicular. Mr. Elliot, in an account published in the 'American Philosophical Transactions,' states that "Lake Erie is situated upon a horizontal strata, in a region elevated about 300 feet above the country which contains Lake Ontario. The descent which separates the two countries is in some places almost perpendicular:


FALLS OF NIAGARA.

and the immense declivity formed by these strata occasions both the cataracts of Niagara, and the great falls of Cheneseco. This remarkable precipice generally runs in a western direction, from a place near the bay of Toronto. On the northern side of Ontario, round the western angle of the lake, from thence it continues its course generally in an eastern direction, crossing the strait of Niagara and the Cheneseco river, till it is lost in the country towards the Seneca lake. The waters of this cataract formerly fell from the northern side of the slope, near the landing place. But the action of such a tremendous column of water, falling from such an eminence, through a long succession of ages, has worn away the solid stone for the distance of seven miles, and formed an immense chasm, which cannot be approached without horror. Down this awful chasm the waters are precipitated with amazing velocity, after they make the grand pitch; and such a vast torrent of falling water communicates a tremulous motion to the earth, which is sensibly felt for some poles around, and produces a sound which is frequently heard at the distance of twenty miles. Many wild beasts that attempt to cross the rapids above this great cataract are destroyed, and if geese or ducks happen inadvertently to alight in these rapids, they are incapable of rising on the wing again, and are hurried on to inevitable destruction. A vapour or spray of considerable density, resembling a cloud, continually ascends, in which a rainbow is always seen when the sun shines, and the spectator is in a favourable direction."

The width of the river, a little above the falls, is nearly three quarters of a mile, and the rocks where it grows narrower are above 400 yards over, or nearly one-fourth of a mile. The water does not precipitate itself down the vast abyss in one entire sheet, but, being separated by islands, forms three distinct collateral falls. One of these is called the Horse Shoe Fall, from the similarity of its form to that of a horse shoe. Its circumference is generally computed at 1800 feet, or more than one-third of a mile. Beyond the intervening island—the width of which may equal 1050 feet—is the *second fall*, about fifteen feet wide; and at the distance of ninety feet, occupied by the second island, *Fort Seloper Fall.* The dimensions of this cataract is equal to those of the large island, so that the entire extent of the precipice, including the intermediate islands, is above 4000 feet. The quantity of water precipitated from the falls is prodigious, and is estimated to amount to

670,250 tons per minute. The horse-shoe fall is the largest and the most sublime. The immensity of the various objects which here present themselves to the view infallibly overwhelm the stranger with astonishment, and several minutes must elapse before he can possibly collect himself sufficiently to form any just conception of the awful and magnificent scene before him, which requires that all its component parts should be separately examined, and which affords so truly surprising an exhibition, that persons who have resided in the vicinity many years, and who have been constantly habituated to its sublimity, acknowledge, at *their last visit*, that they were never able before to discover its peculiar grandeur.

The colour of the water of the cataract, as it descends perpendicularly on the rocks, is occasionally a dark green, and sometimes a foaming brilliant white, displaying a thousand elegant variations, according to the state of the atmosphere, the height of the sun, or the force of the wind. The noise of the falls, and the fury of the waters at the bottom of their fall, is inconceivable. A portion of the spray resulting from the falls frequently towers above the height, and literally mingles with the clouds; while the remainder, broken in its descent by fragments of rocks, is in continual agitation. On the brink, and along the strand to the great fall, are to be constantly seen shattered trees and bodies of animals, which have been carried away by the extreme violence of the current. The noise, irregularity, and rapid descent of the stream, continue about eight miles farther, and the river is not sufficiently calm to admit of navigation till it reaches Queen's Town on the west of the straits of Niagara, nine miles distant from the falls. Just below the great fall, a bridge has been thrown across the Niagara river, uniting the shores of Canada with those of the United States.

Many other cataracts—though of less dimensions—are to be found in America, and likewise in Europe, in the countries of Norway, Sweden, Russia, Switzerland, and many other parts of the world. Near the city of Gottenburg, in Sweden, the river rushes down from a tremendous high precipice into a deep pit, with a terrible noise, and such dreadful force, that those trees designed for the masts of ships, which are floated down the river, are usually turned upside down in their fall, and often are shattered to pieces, by being dashed against the surface of the water in the pit; this occurs if the masts fall side-ways upon the water; but if they fall

end-ways, they dive so far under the water that they disappear for a quarter of an hour or more. The pit into which they are thus plunged has been often sounded with a line of some hundred fathoms long, but no bottom has ever been found.

In our own country, some beautiful and romantic cataracts, though not on a large scale, are to be found. The fall of Fyers, in Inverness-shire, though the stream is not large, descends upwards of 200 feet, and forms a scene of considerable sublimity. The river Clyde in its course forms several romantic falls and cascades. The uppermost, two-and-a-half miles above Lanark, is called *Bonniton*, where the river precipitates itself over a rock twenty-seven feet perpendicular height. It boils and foams and thunders among rocks and precipices till it arrives at a second fall called *Corra linn*. Here the water does not rush over in one but in three different leaps. Two miles below is the third, or *Stonebyre's linn*, about eighty feet in height. It is equally romantic with the others, and has, like Corra, three distinct precipitate leaps.—In Kinross-shire there are likewise three falls, which are frequently visited as natural curiosities. The first is named the *Devil's kiln*, which is situated on the Devon, seven miles west of Kinross. It is formed by the water falling from a cascade into a hollow of the rock below, and makes a noise like a mill driven by a great current of water. 2. About 350 yards below is the *Rumbling bridge*, from the rumbling noise which the water, falling from precipice to precipice, makes in the stream below. The line of the arch is twenty-two feet, the breadth of the bridge eleven, and the height eighty-six feet. It forms a picturesque and somewhat awful scene. 3. The *Caldron linn*, about a mile from the Rumbling bridge, where there are two cataracts, distant from each other twenty-eight yards—the upper thirty-four feet, and the lower forty-four, nearly perpendicular. In the space between the two falls are three round cavities like caldrons. In the first, the water is agitated as if it were boiling; in the second, it is covered with a constant foam; and, in the third, which is twenty-two feet diameter, the water is calm and smooth. The noise of the fall is tremendous, and the rocks seem to tremble to their centre, while the mind is absorbed in wonder and admiration. Many cataracts or falls of a smaller description are found on the rivers of Europe and Asia.

The following is Malte Brun's account of the formation of cataracts. It is only the sloping of the land which can at first cause water to flow; but an impulse having once been communicated to

the mass, the pressure alone of the water will keep it in motion, even if there were no declivity at all. Many great rivers, in fact, flow with an almost uninterrupted declivity. Rivers which descend from primitive mountains into secondary lands often form cascades and cataracts. Such are the cataracts of the Nile, of the Ganges, and some other great rivers, which evidently mark the limits of the ancient land. Cataracts are also formed by lakes: of this description are the celebrated falls of Niagara; but the most picturesque falls are those of rapid rivers, bordered by trees and precipitous rocks. Sometimes we see a body of water which, before it arrives at the bottom, is broken and dissipated into showers, like the Staubach; sometimes it forms a watery arch, projected from a rampart of rock, under which the traveller may pass dryshod, as the "falling spring" of Virginia. In one place, in a granite district, we see the Trohletta, and the Rhine, not far from its source, urge on their foaming billows among the pointed rocks. In another, amidst lands of a calcareous formation, we see the Crettina and the Herka rolling down from terrace to terrace, and presenting sometimes a sheet and sometimes a wall of water. Other cataracts, like those of Tunguska in Siberia, have gradually lost their elevation by the wearing away of the rocks, and have now only a rapid descent.

On the whole, cataracts form some of the most pleasing and some of the most awful combinations of sights and sounds which are to be found in the economy of our globe. Along with other sublime objects, they show us what a variety of interesting scenery the Creator has introduced into our lower world, to gratify the taste, the imagination, and the other powers of man, and to prevent nature from presenting to our view a dull and monotonous scene. We cannot traverse any considerable portion of our world without perceiving the characteristic of *variety* impressed upon all its arrangements, and without meeting with many of the harmonies, beauties, and sublimities of nature. Almost every sense is enraptured with the scenic representations which rush on the mind; and we are at the same time astonished at the apparent simplicity of those principles and laws by which such a vast diversity of scenery is produced. If other worlds, of a magnitude far superior to ours, be diversified with a similar variety of objects, what an immense variety of scenes of beauty, grandeur, and sublimity must exist throughout the countless millions of resplendent worlds which com-

pose the boundless universe. A period of duration, approximating to eternity itself, would be requisite in order that an intelligent being might be enabled to survey all the scenes of divine wisdom, goodness, and omnipotence, and all the august and beautiful objects which exist throughout the boundless empire of the Almighty; and if so, the sources of knowledge and happiness in the future world can never be exhausted, but new objects and enjoyments must be for ever bursting upon the view, while ages numerous as the drops of ocean are rolling on.

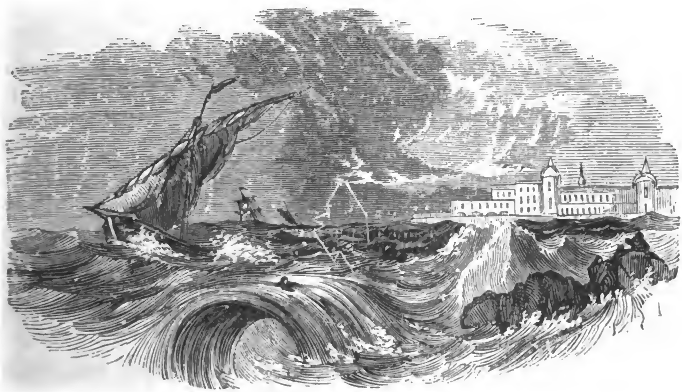
On Winds.—Winds or currents in the atmosphere are nothing more than air in motion, produced by the rarefaction or condensation of the atmosphere by heat, cold, lightning, or other agents. The sun, the source of light and heat, is the chief agent that regulates the wind; and were the surface of the earth equally smooth and equally under the influence of the solar rays, the winds would generally blow from the east. But as the influence of the sun is permanent only over the equatorial portions of the globe, the other parts of the earth must have the winds irregular. When any part of the air is heated by the sun or any other causes, it will swell, and thereby affect the adjacent air, and thus by various degrees of heat in different places, there will arise various motions of the air. When the air is much heated, being thereby made specifically lighter than the adjacent air, it will ascend towards the upper regions of the atmosphere, and the adjacent air will rush in to supply its place; and therefore there will be a current of air from all parts toward the region where it is heated. Thus we find that air rushes with great force into a glass-house, a tile kiln, or towards any place where a great fire is made; and thus it is, in any ordinary apartment, that it rushes in at a key-hole of the door, when there is a fire in the room. A variety of causes operate to produce rarefaction, and consequently to produce winds. Air is contained in most bodies, and is continually flying off; minerals, vegetables, and animals contribute to increase the aerial current, and are constantly sending off their supplies. These, as they are differently affected by cold or heat, by mixture or putrefaction, all yield different quantities of air at different times; and, in conjunction with the operation of the sun, the loudest tempests and the most rapid whirlwinds are formed from their united contribution. The moon, the seasons, and perhaps the other planets are likewise combined in producing these effects in a smaller degree. Moun-

tains give a direction to the courses of the air; fires carry a current of air along their body; night and day alternately chill and warm the earth, and produce an alternate current of its vavours. These and many other causes may be assigned for the variety and activity of the winds, their continual change, and their uncertain duration.

There are different kinds of winds which may be distinguished —1. The *Trade-winds*, so called from their conveniency in carrying on trade by means of the ocean. These winds constantly range in one direction but never extend farther than 30 degrees from the equinoctial, either north or south. That in the northern hemisphere blows always from the north-east, and that in the southern hemisphere from the south-east. This middle point of the winds is caused by the rotatory motion of the earth from west to east. The parts immediately under the sun being heated, the air is rarified and rendered lighter; and therefore, to restore the equilibrium, the air rushes in from the north and south, and consequently makes a current in a direction contrary to that of the earth's motion, namely from east to west. If our globe were stationary, then the wind would rush from the north and south poles, and meet at the equator, which would doubtless cause a most terrific convulsion. These winds are found to prevail in the Atlantic and Pacific oceans; but they are frequently interrupted by the high ranges of mountains that lie in the direction of north and south, such as the Andes in America, and the mountains of Atlas in Africa.

2. The *Monsoons*, or shifting trade-winds, as they are sometimes called, are periodical winds which blow for six months in one direction, and during the other six months in an opposite direction. These winds occur in the Red sea, the Chinese sea, and along the northern part of the Indian or Eastern ocean; and their effects are rarely perceptible more than 600 miles from the land. Their change is supposed to be caused by the earth's revolutions round the sun. This takes place at the vernal and autumnal equinoxes, and is generally accompanied with dreadful storms of thunder, lightning, and rain, called by sailors, "the breaking up of the monsoons." On the west side of the Persian Gulf they set in about September, blowing from the north-east point to the south-west till April, when they change and blow the contrary way during the remainder of the year.—In the south of India the south-west

monsoon commences about the middle of June. Its approach is announced by vast masses of clouds that rise from the Indian ocean, and advance towards the north-east, gathering and thickening as they approach the land. After some threatening days the sky assumes a troubled aspect in the evenings, and the monsoon



THE MONSOON.

generally sets in during the night. It is attended with such a thunder-storm it can scarcely be imagined by those who have only seen that phenomenon in a temperate climate. It begins with violent blasts of wind, which are succeeded by floods of rain. For several hours lightning is seen almost without intermission; sometimes it only illuminates the sky, and shows the clouds near the horizon; at others it discovers the distant hills, and again leaves all in darkness; when, in an instant it re-appears in vivid and successive flashes, and exhibits the nearest objects in all the brightness of day. During all this time, the distant thunder never ceases to roll, and is only silenced by some nearer peal, which bursts on the ear with such a sudden and tremendous crash, as strikes the most insensible heart with dread and alarm.

The Land and Sea Breezes.—These are periodical winds that blow off the land from midnight to mid-day and of the sea from about noon till midnight. They do not generally extend above eight or nine miles from the shore, and are chiefly observable in

the East and West India islands. In some countries the sea breeze sets in about ten in the forenoon, and blows till six in the evening; at seven the land breeze begins and continues till eight in the morning, when it dies away.

VARIABLE WINDS.—From the equator to the poles in both hemispheres, the winds are very irregular and uncertain both as to violence and direction, though most countries have some particular breeze more prevalent than the others. These winds chiefly prevail towards the northern and southern regions of the earth, beyond 30 degrees of north and south latitude. In Great Britain the principal points from which the winds blow are the north-east and the south-west. The south-west wind blows nearly eight months in the year, and the north-east for nearly four months, chiefly in the months January, February, April, and May. Winds from the south, the north, and north-west seldom continue for any length of time.—In our climate the wind seldom occasions much alarm, as its effects are rarely injurious to any great extent; but between the tropics its awful and terrific powers are felt in all their violence.

It has sometimes happened, however, even in our temperate region, that winds have produced the most awful and destructive effects. One of the most dreadful storms of this kind happened in England on the 27th November, or according to the new style, on the 8th December, 1703. On the morning of Friday the 26th it raged so fearfully that only few people had courage to venture abroad. Towards evening it rose still higher, the night setting in with excessive darkness added horror to the scene, and prevented any from seeking security abroad from their homes, had that been possible. The extraordinary power of the wind created a noise hoarse and dreadful like thunder, which appalled every heart. "Horror and confusion (says De Foe) seized upon all whether on shore or at sea; no pen can describe it, no tongue can express it, no thought can conceive it, unless theirs who were in the extremity of it. To venture abroad was to rush into instant death, and to stay within afforded no other prospect than that of being buried under the ruins of a falling habitation. Some in their distraction did the former, and met death in the streets; others the latter, and in their own houses received their final doom." One hundred and twenty-three persons were killed by the falling of dwellings, among whom were the bishop of Bath and Wells and his lady, by

the fall of the Episcopal palace, and lady Nicolas, sister to the bishop of London. Those who perished in the waters—in the floods of the Severn and the Thames, on the coasts of Holland, and in ships blown away and never heard of afterwards, are computed to have amounted to *eight thousand.* All ranks and degrees were affected by this amazing tempest; land, houses, churches, corn, trees, rivers, all were damaged by its fury. Small buildings were for the most part wholly swept away "as chaff before the wind." Above 800 dwelling houses were laid in ruins; 2000 stacks of chimneys were blown down in London; and when the day broke the houses appeared as so many skeletons. Innumerable trees were torn up by the roots; multitudes of cattle were lost; on the banks of the Severn 15,000 sheep, and in the county of Kent about 20,000. The ships lost by the storm were estimated at 300. In the Thames 500 wherries, 300 ship boats, and 100 lighters and barges were entirely lost. The damage done in the city of London was computed at £2,000,000 sterling, and at Bristol at £200,000. The first Eddystone lighthouse, near Plymouth, was precipitated in the surrounding ocean, and with it Mr. Winstanley, the ingenious architect by whom it was contrived, and the people who were with him.—As one instance, among many others, of the amazing strength and rapidity of the wind, the following may be stated: Near Shaftesbury, a stone of 400 pounds weight, which had lain for years fixed in the ground, fenced by a bank with a low stone wall upon it, was lifted up by the wind, and carried into a hollow way distant at least 21 feet from the place. And, in a country town, a large stable was at once removed off its foundation, and instantly carried quite across the highway, over the heads of five horses and the man that was then feeding them,

THE EDDYSTONE LIGHTHOUSE.

without hurting any one of them, or removing the rack or manger.

Noxious Winds.—1. The *Simoom*. This wind prevails in Egypt and in the sandy deserts of Arabia and Africa. It generally blows from the S. or S.W. and lasts five or six days without variation. Its force is such that it raises the sands of the great desert to an extraordinary height, and carries them along in the form of a huge cloud so densely thick that it is impossible to keep the eyes open if not under cover. When it begins to blow, the sky loses its usual serene aspect, and assumes a dark and alarming appearance. The sun no longer shines with its wonted effulgence, but becomes of a deep violet colour, caused by the floating particles of sand in the atmosphere. The motion of this cloud of sand resembles that of a fluid, and the whole plain seems to float onward like a slow inundation. It penetrates every chink and fills every place in its progress. The body of sand thus rolling is deep enough to bury houses and palaces in its bosom. Such is its power and force that caravans cannot proceed in the desert, boats cannot continue their voyages, and, when it is extremely rapid, no swiftness or art of travellers is sufficient to avoid it, nothing remains but to meet death with fortitude, and submit to be buried alive with resignation.—Its effects on the human body are dreadful. If inhaled in any quantity, it produces instant suffocation, or at least leaves the unhappy sufferer oppressed with asthma and lowness of spirits.

THE SIMOOM.

2. The *Sirocco*.—This wind is frequently felt in Greece, Italy, and southern Europe, and is occasioned by the passage of a current of air over the heated sands of Zahara, which renders it so dry and rarified as to be unfit for respiration in that country. This

wind is prejudicial to plants, drying and burning up the buds, and to men by causing extraordinary weakness and lassitude. During its continuance its effects are so dreadful that life becomes a burden, and the poor sufferer would willingly lay himself down to die, for his faculties become so stupified that all his energies forsake him.

3. The *Samiel.*—This is a very dangerous and noxious wind, which prevails along the coasts of the Persian gulf and the deserts of Arabia. It blows over the desert in the months of July and August, from the north-west quarter, and sometimes rushes on with unabated violence to the very gates of Bagdad, but never affects any person within the city. Some years it does not blow at all, and sometimes it appears six, eight, or ten times in the course of a year, but seldom continues longer than a few minutes at a time. It often passes with the apparent quickness of lightning. The Persians and Arabians are warned of its approach by a thick haze that appears like a cloud of dust rising in the horizon, immediately on seeing which they throw themselves with their faces to the ground, and continue thus prostrate till the wind has passed, which frequently happens to be almost instantaneous; but if they are not careful or vigorous enough to take this precaution, they receive the full force of the wind, and the consequence is *instant death.* When the blast is over, they get up and look around them for their companions; and if they see any one lying motionless, they take hold of an arm or leg, and pull or jerk it with some force, and if the limb separates from the body, it is a certain sign that the party is dead; but if the arm or leg does not come away, it is a sure sign that there is life remaining, although the person appears dead. This wind is so well known in the neighbourhood of Bagdad and Bassora, that the very children talk of its destructive effects with dread and alarm. Thevenot states that when he journeyed from the isthmus of Suez to Cairo, about the end of the seventeenth century, he was greatly annoyed by one of these hot winds, which lasted for a whole day, and that the caravan travelling to Mecca was so infested by one the year before, that they lost 2000 men in a single night.

4. The *Harmattan* is the name of a periodical wind which blows from the interior parts of Africa towards the Atlantic ocean, and is prevalent on the western coast between cape Verd and cape Loper. It is thought to be produced through the Trade winds being interrupted in their course as they pass over the deserts of

Africa. They occur between the months of December and March. This wind continues sometimes only a day or two, sometimes six days, and it has been known to last fifteen or sixteen days. There are generally three or four returns of it every season. It is always accompanied with a fog or haze, and a dismal gloom. The sun, concealed the greater part of the day, appears only a few hours about noon, of a ruddy colour. Extreme dryness is another extraordinary property of this wind. No dew falls, nor is there the least appearance of moisture in the atmosphere. Vegetables of every kind are very much injured; all tender plants and garden productions are destroyed; grass withers, and becomes dry like hay; the branches of the lemon, orange, and lime trees droop, and are so parched as to be easily rubbed to dust. The parching effects of this wind are likewise evident on the external parts of the body. The eyes, nostrils, lips, and palate are rendered dry and uneasy; the lips and nose become sore, and even chopped, and there is a troublesome sensation of prickling heat on the skin. If the harmattan continues four or five days, the scarf skin peels off from the hands and face, and afterwards from the other parts of the body. Even the birds and beasts droop under the baneful influence of this ungenial temperature, and the very woods seem to shrink from the pestilential vapour.

5. *Hurricanes.*—In the West India Islands and around the Cape of Good Hope violent storms called hurricanes frequently occur. The ruin and desolation accompanying a hurricane can scarcely be described. Like fire, its resistless force consumes every thing in its track in the most terrible and rapid manner. It is generally preceded by an awful stillness of the elements, and a haze in the atmosphere, which makes the sun appear red and the stars larger. But a dreadful reverse succeeds. The sky is suddenly overcast and wild—the sea rises at once from a profound calm into mountains—the wind rages and roars like the noise of cannon—the rain descends in deluges—a dismal obscurity envelopes the earth with darkness—the superior regions appear rent with lightning and thunder—the earth seems to tremble, and consternation distracts all nature. The birds are carried from the woods into the ocean; the frightened animals in the field assemble together, and are almost suffocated by the wind while seeking shelter. Roofs of houses are carried to vast distances, and their walls beaten to the ground, burying their inhabitants under them. Large trees are

torn up by the roots, and driven through the air in every direction. Harbours are covered with wrecks of boats and vessels, and the shore left without a vestige of its former state, and the dead and dying bodies of men, women, and children, half buried, and scattered about on every hand. Near the Cape of Good Hope such storms are preceded by an extraordinary cloud called *the bull's eye*, because, when first seen, it looks like a black spot at an immense distance on the very verge of the horizon. During its progress a hollow murmuring sound is heard issuing from the cavities of the mountains and rocks, and animals, sensible of its approach, are seen fleeing across the plains seeking shelter. The sun which, for a moment before, shone with meridian splendour, is now lost to sight, and midnight gloom prevails, except that the sky is ever and anon illuminated with flashes of lightning, so fierce and strong that a person may easily see to read; at the same time the rain comes down in the most violent torrents. Our sailors are now aware of the prognostics of such storms, and they instantly strip their masts of all their sails, and thus with bare poles calmly abide the fury of the elements. These destructive phenomena are now supposed to arise from electricity, in combination with other agents which produce winds and storms. The dangerous wind called the white squall is also well known.

Winds are of essential service in the economy of nature and art. By this mechanical force of the atmosphere, ships are impelled across seas and oceans to the remotest corners of the globe, and thus commerce and friendly intercourse are promoted between distant tribes and nations. By this power wind-mills and other machinery are set in motion to perform operations subservient to the benefit of man. In the system of nature, the winds purify the atmosphere, which by a long stagnation would prove unwholesome and pestilential, without those agitations which gales and breezes produce. We find from experience how putrid and unfit for respiration, as well as for health and pleasure, is a stagnant atmosphere pent up without agitation. Were the whole mass of vapours always at rest, and without the least motion, the atmosphere, instead of animating and refreshing, would soon produce pestilential effluvia which would suffocate and destroy all the tribes of the living world. But the perpetual commotions it receives from gales and storms

have a tendency, on the whole, to preserve it pure and healthful, without which our habitations would be infectious and unwholesome, and London and Paris, and other large cities, would in a short time become as nauseous as a common sewer. Such ventilations in the atmosphere are not only beneficial to health, but to the *pleasure* also of the inhabitants of the world. Such are the breezes and gales that fan us in the heat of summer, without which travellers could scarcely prosecute their journeys, or the bulk of men be able to perform the labours of their respective callings. Without the gales which fan the torrid zone, that portion of our globe would be rendered almost uninhabitable.—When our cattle begin to droop and faint through a long series of sultry weather, when the verdure of the meadows begin to fade, the sea often sends at a seasonable juncture a westerly wind, which brings with it the wished for succours of refreshment.—The winds, then, are the servants of mankind, under the superintendence of the Creator. They keep our houses clean and free from infection; they convey away whatever is offensive and may pollute the air without being discerned by the most curious eye.

But notwithstanding these obvious benefits we derive from the winds, it does not appear probable that they formed a part of the original constitution of our globe, *in the manner in which they now operate*. We can scarcely conceive that such winds as the samiel and sirocco, and the furious and appalling hurricanes, would prevail while man remained in his primeval innocence; and therefore, we have reason to believe that an important change took place in the system of our earth and atmosphere, particularly at the period of the deluge, by which the elements of nature now operate as we actually find them. This world, in its present state, appears to be chiefly adapted to a race of depraved intelligencies, and the awful thunders and the frightful tempests seem intended by the Creator as a demonstration of his terrors, that men may be compelled to fear and reverence Him whose laws they have violated. At the same time, it is in the power of man to mitigate storms and tempests by the universal cultivation of the earth, and it is probable this will be carried more fully into effect when the human race shall arrive to a greater degree of moral and intellectual perfection. It is found by experience that cultivation has a tendency to meliorate the seasons. Since the forests of Canada and the Eastern portions of the United States of America were

cut down, the marshes drained, the soil cultivated, and other improvements carried forward, it has been remarked that it is neither so cold in winter, nor so sultry in summer, in those cultivated districts as when the land remained in its natural state, abounding in marshes, and buried under almost interminable forests. And were the sands of the African deserts brought into a state of cultivation, those pestilential winds which prevail in such countries, such as the Samiel and Simoom, might be in a great measure prevented. This, it is conceived, is possible to be effected, among other means, by erecting an extended series of elevated metallic conductors, which would arrest the clouds in their course, and draw down their electricity and their watery treasures. But before such improvements would be thoroughly effected in any country, man must not only improve in science and the arts, but in the practice of Christian principles, and of all those heavenly virtues which have a tendency to promote good will, harmony, and union among all the branches of the human family. Without harmony, love, and mutual co-operation, no extensive improvements could be effected in the physical economy of our globe; for where selfishness, avarice, revenge, and other malignant passions prevail among families, communities, or nations, all such operations are apt to be impeded or counteracted. Hence the reason why improvements, in relation to the state of society, make so slow advances even among civilized nations. But when the millennial era of the world shall have introduced the full display of the Christian virtues, then we may expect that every desirable improvement will be harmoniously effected, our globe renovated and enriched with fertility, and "the wilderness made to bud and blossom as the rose."

Waiving the consideration of other particulars I shall simply state some of the artificial divisions of the earth, and two or three facts respecting its inhabitants.

The Land has generally been divided into four parts, Europe, Asia, Africa, and America, to which has been lately added the division called Australasia, which comprehends New Holland, New Guinea, New Zealand, Van Dieman's Land, and several other islands in the Pacific ocean.

Europe, one of the five grand divisions of the world, comprehends the following countries:—Norway, Sweden, Denmark, Lapland, Russia, Prussia, Germany, Austria, Turkey, Italy, Switzer-

land, France, Holland, Belgium, Spain, Portugal, and Great Britain and Ireland, together with the islands of Sicily, Malta, Candia, Corsica, Sardinia, Majorca, Minorca, Ivica, Zealand, Funen, Gothland, Iceland, and several others of smaller note.

Europe is the smallest of the five grand divisions of the globe. Its greatest extent is from north-east to south-west, namely from the mouth of the Kara in N. Lat. 68° 40′ to the Rock of Lisbon in N. Lat. 38° 45′, which is computed at 3400 British miles. Its greatest breadth, from Cape Matapan, in the Morea, to the North Cape of Norway, is computed at 2350 miles. Its superficial contents have been computed at 3,650,000 square miles, or 2,336,000,000 English acres, reckoning 640 to the square mile. Its form is singularly broken and varied, being split into many distinct portions, peninsulas and large islands with extended and winding coasts, which arises chiefly from the number of its inland seas, of which the Mediterranean, the Baltic, and the Black sea, are the most important. Its *rivers* are numerous, the largest of which are the Rhine, the Rhone, the Wolga, the Danube, and the Thames. Its *mountains* do not reach that stupendous height nor extend in such unbroken chains as those of Asia and America. Its highest ranges are the Alps and Pyrennees, the Appenines in Italy, and the Dofrafield in Norway. Its *lakes*, though numerous, are comparatively small; those of Ladoga and Onega alone being of any commercial importance. Its *soil* is distinguished for its valuable productions: Grain of different kinds is raised over its whole surface, except the extreme north—wines throughout all its southern region, and it is equally productive in hemp, flax, wool, and silk. Its northern forests produce some of the finest timber in the world; and the iron of Europe surpasses that of any other country. The cultivation of the soil is carried on with great diligence, and in point of science, skill, and the extent of capital employed upon it, and upon every branch of commerce and manufacture, it stands unrivalled among the other countries of the globe. Its commerce is on a very extensive scale, and in manufacturing skill it has surpassed every other country, both in the variety and the cheapness of its productions. European vessels, conveying articles and manufactures of all descriptions, are to be found at the utmost bounds of Asia and America, in the snowy regions of the poles, and crowding the ports of Australia, and exchanging various commodities for its newly-discovered gold—New Zealand, and the islands of the Indian and Pacific oceans.

The *population* of Europe is now reckoned to amount to about 260,000,000. Its inhabitants are divided chiefly into three races, the Sclavonic, Teutonic, and Romish races. The *Sclavonic* consists of about 25,000,000 of Russians, 10,000,000 of Poles, and 10,000,000 in other adjacent countries. The *Teutonic* race, which occupy the greater part of Germany, Belgium, Holland, and Great Britain, may be estimated at 55,000,000. The *Romish* race includes the inhabitants of Southern Europe, France, Italy, Spain, etc., and may be estimated at about 80,000,000. The Celts in Scotland, Ireland, Wales, and Spain, are the remains of the most ancient inhabitants of Western Europe, and may amount to about 7,000,000. The Greeks in Europe amount to 2,000,000, and the Jews throughout all Europe to about 2,000,000. The Tartars, Turks, Hungarians, and Gypsies, who are of Asiatic origin, amount altogether to 6,000,000 or 7,000,000. Though this division of the earth is least in point of size—being only the one-sixteenth

THE TEA PLANT.

THE COFFEE PLANT.

part of the terraqueous globe—it is yet by far the greatest as to moral, political, and commercial importance. Its surface is in general more crowded with inhabitants than most other countries (China alone excepted), more improved by cultivation, more en-

riched by industry and commerce—embellished with mighty cities and splendid works of art, and illumined with the reflections of genius. Here we behold mind asserting its supremacy over matter, and man, the lord of this lower world, pursuing the high destiny originally assigned him, to "replenish the earth and subdue it." In learning, arts, and sciences, Europe has far surpassed every other portion of the globe; and by the invention of printing, knowledge of every description is now rapidly diffused, and promoting the moral and intellectual improvement of its population.

Asia, the largest and most populous division of the ancient continent, contains the empires of China and Japan, Chinese Tartary, Thibet, Hindostan or British India, the Birman Empire, Persia, Arabia, Turkey in Asia, Russia in Asia, Independent Tartary, and a variety of territories inhabited by tribes with which we are very imperfectly acquainted; together with the immense islands of Australia, New Zealand, Bornea, Sumatra, Java, Ceylon, Segalian, the Philippines, and thousands of others of smaller dimensions. The immense expanse of Asia presents every possible variety of soil and climate, as it extends from the confines of the polar regions to the tropical climes. Its grandest feature is a chain of mountains crossing it from the Mediterranean to the Eastern seas, of which Taurus, Caucasus, and the Himalaya are the portions best known. One leading feature of middle Asia consists in large lakes or inland seas, salt like the ocean, and having no outlets; of which the Caspian, the sea of Aral, and Baikal, are the largest. It contains many rivers of great magnitude. The Euphrates, the Ganges, the Hoangho, and the Amur, in the length of their course, yield only to the rivers of America. This quarter of the globe is reckoned to be 7500 miles in length, from east to west, and about 5000 miles in breadth, from south to north, and contains about 16,000,000 of square miles, being more than four times larger than Europe. Its inhabitants have been computed by some writers to amount to 600,000,000. It was in Asia where the human race was first planted; it became the nursery of the world after the universal deluge, and it was the scene in which the most memorable transactions recorded in the sacred history took place. But its inhabitants are now immersed in Mahometan and Pagan darkness; and the Christian religion, except in some few isolated spots, is almost unknown among its vast

population, though Christianity has recently found many supporters in China and British India. It is the richest and most fruitful part of the world, and produces cotton, silk, spices, tea, coffee, gold, silver, pearls, diamonds, and precious stones: but despotism, in its worst forms, reigns uncontrolled over every part of this immense region.

Africa comprehends the following kingdoms:—Morocco, the

AFRICAN FEMALE.

French Colony, Algeria, Tunis, Tripoli, Egypt, Zaara, Negroland, Guinea, Nubia, Abyssinia, Caffraria, Dahomy, Benin, Congo, Angola, the British Colony at the Cape of Good Hope, and various other territories, with Madagascar, and several smaller islands. By far the greater part of Africa remains hitherto unexplored, and consequently we are possessed of a very slender portion of information respecting the numerous tribes that may inhabit its

interior. This quarter of the world, which once contained several flourishing kingdoms and states, is now reduced in great part to a general state of barbarism. That most abominable traffic, the slave trade, is still carried on to a limited extent on its western coasts, by a set of European ruffians, whose villanies are a disgrace to human nature. It is to be hoped this traffic will, ere long, be extirpated by the efforts now making by European nations, and by the plans which are now concerting for promoting the religious, moral, and commercial improvement of this country. The Christian religion has lately been introduced into its southern regions, in the districts adjacent to the Cape of Good Hope, and the labours of missionaries of different denominations appear, in numerous instances, to have been crowned with remarkable success.[1]—A colony of blacks, formerly slaves in North America, has lately been established on the western coast, a little to the south of the island of Sierra Leone, which is known by the name of *Liberia.* All the affairs of this little state are conducted by emancipated negroes, and particular attention is paid to the literary and religious instruction of the colonists. Some of the newspapers we have seen, published by the settlers in this colony, indicate a considerable degree of talent and information; and there is a prospect that the improvements going forward in Liberia will, ere long, produce a beneficial influence on those tribes which occupy the adjacent territories, and have a tendency to lessen the traffic in slaves. The greatest breadth of Africa is about 4790 miles, and its length from north to south about 5000 miles. Its most striking features are those immense deserts, near its northern parts, which comprise nearly one third of its surface. The deserts of Zaara are 1500 miles long and 800 broad.

America is divided into North and South. It remained unknown to the inhabitants of the Eastern hemisphere till the year 1492, when it was discovered by Columbus, who first landed on Guanahani, or *Cat Island,* one of the Bohama isles. It obtained its name from Americus Vespusius, one of the navigators who followed in the path of the great Columbus. North America comprehends the following countries: the United States, New and Old Mexico, Upper and Lower Canada, Nova Scotia, New Brunswick, and Labrador. South America comprehends the immense districts called

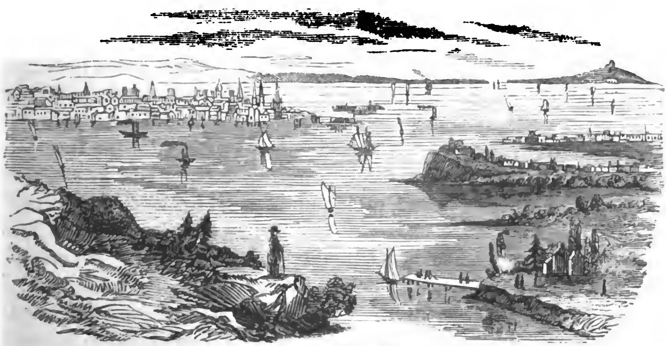
1 See Moffat's interesting work, entitled 'Missionary Scenes and Labours in Southern Africa.' 1842.

Terra Firma, Peru, Guiana, Amazonia, Paraguay, Brazil, Chili, and Patagonia,—Between N. and S. America lie the islands of Cuba, St. Domingo, Jamaica, and Porto Rico—the group known by the name of the *West Indies.* America is bounded on the east by the Atlantic, on the west by the Pacific, and on the north by the Arctic ocean, where its limits, owing to the intense cold, are but imperfectly known. South America comprises a surface of 6,500,000 square miles, its length being 4500 miles, and its greatest breadth 3200 miles. North America, exclusive of the islands that surround it, contains about 9,000,000 of square miles. It has been divided into five physical regions: 1. The table land of Mexico, 2. The slope lying between the rocky mountains and the Pacific ocean, 3. The great valley of the Mississippi, 4. The eastern declivity of the Alleghany mountains, 5. The great northern plain beyond 50° north latitude, a bleak and barren waste, covered with lakes. Besides these, there are connected with America, the Bahama and Caribbee islands; Newfoundland, Cape Breton, Tobago, Trinidad, Terra del Fuego, etc. America is distinguished by its numerous and extensive lakes, which resemble large inland seas. Its rivers also form one of its grand and distinguishing features, being the largest on the globe. It is likewise diversified with lofty and extensive ranges of mountains. When first discovered, it was almost wholly covered with immense forests and thinly peopled with a number of savage tribes. Its mingled population is now making rapid advances in knowledge, civilization, and commerce, though the aboriginal inhabitants are rapidly decreasing before the march of Anglo-Saxon civilization.

The *United States,* which extend from the 20th to the 50th degrees of north latitude, form the greatest and most influential power that exists on this continent, and possess a territory of vast extent—stretching from the great lakes to the gulf of Mexico, a breadth of about 1600 miles; and from the Atlantic to the Pacific ocean, a length of 2700 miles, including a surface of 2,500,000 square miles. The population of these States now amounts, according to the last published census, to upwards of 18,000,000—an astonishing number, when we consider that only a little more than two hundred years ago these territories consisted merely of immense forests and great tracts of treeless wilderness, called prairies, peopled by a few tribes of savages. Were the whole ex-

tent of the United States brought to a cultivated state, they would be sufficient to subsist a population of 300,000,000 or 400,000,000. These States have been peopled from different European nations, particularly from Great Britain and Ireland, and the English language prevails over most of the thirty States. The form of government is that of a republic; and in religion they have adopted the system of cutting off all connexion between church and state. Every sectary chooses its own pastor and provides entirely for his support. Literature and science have not yet reached the high elevation they have attained in Europe; but numerous colleges, highly respectable, and literary institutions of various descriptions, have been established—some of which enjoy a high reputation. The education of the mass of the community forms a prominent object of attention in each state; and the benefits of a good common education are perhaps more generally diffused than in any other country in the world. It is much to be regretted that the system of slavery still prevails in the *Southern* states notwithstanding all the remonstrances which have been made against it by the inhabitants of the Northern States, and by other nations. But it is to be hoped that the good sense of the inhabitants of these states will, ere long, excite them to arouse themselves to remove that blot upon their national character by which their institutions have been so long and so deeply disgraced. The republic of the United States consists of thirty sovereign states, besides the district of Columbia, the territories of Minesota and Oregon, and other lands west of the Mississippi, which are still more or less inhabited by tribes of wandering Indians. Added to these, the recently acquired territories of New Mexico and California. The latter of which, tracts of country has been found to be extremely rich in gold and other metals. The United States may be classed in four great divisions: 1. The Eastern States or New England, comprising Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. 2. The Middle States—New York, New Jersey, Pennsylvania, Delaware, and Maryland. 3. The Southern States—Virginia, North Carolina, South Carolina, Georgia, Florida, Alambania, Mississippi, Louisiana, and Texas. 4. The Western States—Arkansas, Tenessee, Kentucky, Ohio, Michegan, Illinois, Indiana, Missouri, Iowa, and Wisconsin. Each of the thirty States constitutes a republic independent of the others, with respect to those affairs which are purely local; but matters of

general interest, such as providing for the defence of the country, and the regulation of its intercourse with foreign nations, fall within the province of the federal government. The legislature of this government is vested in a Senate and House of Representatives. The members of the latter are elected every two years by the people; the senators are appointed by the state legislators, two being chosen by each state, for the term of six years—the executive power is entrusted to a President, who holds his office for a term of four years. The President is commander-in-chief of the army and navy, and has the power, in conjunction with the Senate, to make treaties, appoint ambassadors, and other public ministers, the judges of the Supreme Court, and the various executive officers of the general government. The Vice-President presides over the Senate, and in case the votes are equally divided, is permitted to decide by a casting vote. In the event of the President's death, he becomes President for the remainder of the term. Washington



NEW YORK.

is the seat of government, and New York is the principal commercial port.

Australasia is the name given to a number of large islands occupying a portion of the Indian or Southern Pacific ocean between the 10th and 45th degrees of south latitude. The chief island in the group is *Australia* or New Holland, the largest island in the world, being about 2400 miles in length, from east to west, and 1800 from north to south, comprising an area of nearly 3,000,000 of square miles. The country is generally flat, with the exception of some mountain ranges, and in many places the *in-*

clination is inwards, instead of outwards to the sea, so that the mountains and elevated land form a ridge nearly round it. The great kangaroo is the largest quadruped in this country, and the total absence of such animals as lions, tigers, deer, oxen, horses, and bears, is the most striking feature in this region. The aborigines are of the Malay race, and existed till lately in the lowest state of degradation and barbarism. — Four British settlements have been formed in New Holland: 1. *New South Wales,* which stretches about 1400 miles along its eastern coast, and some hundreds of miles inland. This is the oldest and most populous of the Australian colonies, and was selected at first for the transportation of convicts, though voluntary emigrants, of late years, have emigrated thither in considerable numbers. It lies at the distance of about 16,000 miles from Great Britain; but the voyage to it is generally accomplished in from sixty to ninety days. Its capital, *Sydney,* pleasantly situated on a fine bay, called Port Jackson, is now considered as containing a population of 25,000. The whole population of this colony, free and convict, is calculated to be about 110,000, and it is rapidly increasing. 2. Western Australia, or the *Swan-river settlement,* which is not so populous, nor does it appear so prosperous as the other settlements. 3. *South Australia* —which lies on the southern shore. In this colony slavery is not permitted to exist, nor are any convicts allowed to be sent to it from England. Here learning and religion are greatly encouraged, and every mean has been employed by the directors of the South Australian company to render the settlers, as far as possible, a moral and religious population. The capital is *Adelaide,* which already contains about 7000 inhabitants, although it is only about thirty years since the colony was established. Each denomination

THE KANGAROO.

of Christians supports its own ministers and places of worship; and already about £15,000 have been expended in Adelaide and its vicinity in erecting chapels for Christian worship. £5,000,000 of capital have been invested in this province up to the year 1855, 600,000 acres of land have been surveyed. The climate is one of the finest and most salubrious in the world, and it has sometimes been alluded to as "the fair and fertile provine of South Australia." Its winter, which is mild, is in May, June, and July; and its summer in November, December, and January. 4. *Victoria,* or Port-Phillip—the population of this colony—the chief seat of the recent gold discoveries—is estimated at not less than 300,000 in this present year, 1855. The census of April, 1854 gave the exact number as 232,872. Now, when we come to consider that in 1846, the population of Victoria was only 32,879,—less than that of a moderately busy country town in old England—and that in 1851 it had risen only to 77,345, the increase may be considered one of the most remarkable facts in history. According to the rate of increase during the last four years, and reckoning the emigration from Europe as averaging not less than 100,000 per annum—a not extravagant estimate when we consider that no fewer than 200,000 persons landed in New York alone in 1852. We may fairly calculate upon Victoria numbering ten millions of inhabitants in 1865, a population nearly equal to that of Scotland, allowing, of course, for the natural rate of increase of births over deaths—about 33½ per cent. in five years—this calculation will give to the colony of Victoria in 1870, a population of not less than nine millions. The chief city of Victoria is Melbourne. The extent of Victoria is about equal to that of Great Britain. The revenue of the colony of Victoria in 1851 was only £499,000; in 1854 it amounted in round numbers, to £3,500,000—a sufficient proof of the value of the gold discoveries in Australia. The taxes of Great Britain amount to about £2 10s. per head; in Victoria they are not less than £10—another proof of the wealth of the colony. The government of Victoria is vested in a Governor, Colonial-Secretary, Attorney-General, Colonial-Treasurer, Collector of Customs, and the necessary staff of Clerks, and a Legislative Council—eight members of which are nominated by the head governor, and thirty-five by the voters, who must be natural-born subjects of Queen Victoria, and have attained the age of twenty-one. These, with the police and other

municipal officers, constitute the civil government of the colony of Victoria.

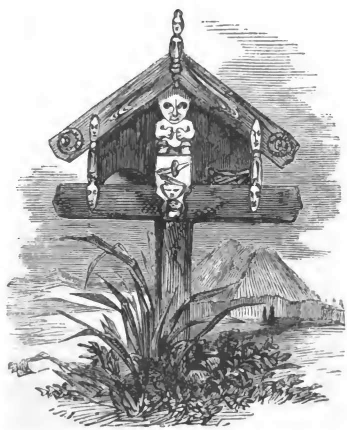
Van Dieman's Land is an island of about the size of England, which is separated from Australia by a channel 90 miles wide, called Bass's Strait. Its shape is nearly that of a parallelogram. It is more hilly and better watered than Australia, and possesses many excellent harbours. Its capital is Hobart Town, situated on the southern side of the island, and on the northern shore is Launcetown, the second town, and a busy seat of trade. The population of the island was lately estimated at 30,000, of which about one half were convicts. Gold has also been discovered in this island.

New Zealand consists chiefly of two large islands, called the Middle Island, and the North Island, separated by a passage called Cook's Straits, with numerous smaller isles scattered around their shores. They lie in an easterly direction from New Holland, at a distance of about 1200 miles from that continent, between the 34th and 48th degrees of south latitude, and the 166th and 179th of east longitude. The southern island is about 500 miles long, and nearly 120 broad. The northern is about 400 miles long, and from five to thirty broad. Both the islands are estimated to contain 95,000 square miles, of which two-thirds are fit for cultivation. Numbers of fine streams and rivers are scattered through the country, and the bays and harbours are not surpassed, either in number or advantages, by those of any country in the world. A chain of mountains runs through the whole of the southern and a considerable part of the northern island, some of the tops of which are as high as 14,000 feet above the level of the sea, and present a highly picturesque appearance. All accounts agree that the climate is highly salubrious, and very congenial to European constitutions. The natives of this country were formerly savage and dangerous, but are now partially improved and comparatively harmless in disposition, the missionaries having now acquired a considerable influence over certain tribes. It is universally admitted that they are a robust and healthy looking people; and Captain Cook observes that he never saw a single person among them who appeared to have any bodily complaint, and that their wounds healed with astonishing rapidity. The entire population of this country has been estimated at 160,000, which is at the rate of six persons to three square miles. The *New Zealand Company* for colonizing this country was established in May, 1839, and is

now actively employed in carrying its plans into effect. Land was purchased from the natives, and a considerable number of adventurers took possession of certain districts. A township was formed on the shores of Port Nicholson—a fine harbour in the Northern Island about the centre of Cook's Straits—named Wellington, which is the capital of the colony. Emigration to New Zealand is now regularly organised.

Some years since the islands of New Zealand were explored in their length and breadth, by George French Angas, Esq., a young gentleman of genius and unwearied perseverance, who returned to London with an immense variety of specimens of its productions and curiosities. In the course of three years' wanderings in that country, he made himself acquainted with its martial tribes; and as an artist, employed himself in the accurate delineation both of the country and of the people. He succeeded in making upwards of 250 admirable paintings of the natives of New Zealand and New Holland,—together with a fine collection of objects of natural history, costumes, idols, temples, tombs, domestic utensils, ornaments,

NEW ZEALAND CHIEF.



NEW ZEALAND STOREHOUSE.

weapons, etc. These curiosities were arranged in a splendid austral museum in the Egyptian Hall, London. From these, and the descriptions connected with them, were derived the best picture that

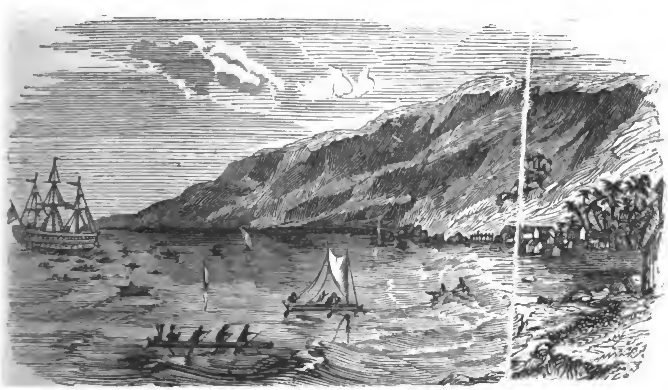
could be exhibited of the peculiarities and the then state of that country, to which so many of our countrymen have since emigrated.

New Guinea, next to Australia, is the largest island of this group, being 1400 miles long. It is inhabited by Papuans, with the still ruder race of Haraforas in the interior. This island is said to be one of the finest countries in existence, producing most of the rich fruits of the torrid zone, such as cocoas, nutmegs, cloves, and spices of all kinds, and is everywhere covered with lofty forests. The Papuans are much farther advanced in civilization than the New Hollanders, but few Europeans have yet attempted a settlement in this island.—*New Britain, New Ireland,* and several others compose a group inhabited by Papuans. The Archipelago, called the *Solomon's Islands,* is inhabited by Papuans, with a mixture of Malays.

Polynesia, or "the many isles," includes the numerous group of islands with which a considerable portion of the Pacific ocean is diversified. They principally lie in an easterly and north-easterly direction from Australasia, within about thirty degrees on both sides of the equator. They are many thousands in number, and are inhabited by barbarous races, who have generally been found more tractable than the barbarous tribes of other parts of the world. They may be divided into the great groups of the *Society, Sandwich, Marquesas, Friendly, Navigator's, Caroline* and *Marianne island's,* with several others. Most of these islands are fruitful and beautiful; some are exceedingly high and romantic, and their climate is reckoned the most delicious on the globe. The *Society* islands, though not the largest, are the most beautiful, and those in which civilization and polished manners have made the greatest progress. Tahiti, the largest in the group, is one of the brightest gems of the Pacific, as the people of this island were the first to abjure Paganism and to embrace Christianity. It consists of two peninsulas, joined by a narrow isthmus. The one is about twenty-five miles long and about the same in breadth. The other is about twenty miles in length by fifteen in breadth. The religion of the natives, like that of the Tonga, Sandwich, and other islanders, was, till within these twenty or thirty years, idolatry of the most barbarous kind, their manners were extremely licentious, and their dispositions sometimes ferocious and cruel. They were perpetually at war among themselves, and their contests were of the most relentless and cruel chracter. But, in consequence of the labours of Christian missionaries, the majority of the inhabitants of this and the adjacent islands have made an open profession of Chris-

tianity. Their places of idolatrous worship have been thrown down, their idol gods destroyed, and an end put to their ferocious and destructive wars. The whole of the sacred Scriptures has been translated into their native language; they are learning to read the word of God; and, in numerous instances, they have made a wonderful progress in studying its facts and doctrines, and in practising those duties which it enjoins. The consequence has been that they have made a great improvement in all the arts and accommodations of life. They have built ships, engaged in manufactures of different kinds, reared spacious places of worship, established schools and other seminaries of instruction, erected villages adorned with neat and commodious habitations, and have made astonishing progress in the cultivation of the soil. The moral transformation and improvements which have been effected among the inhabitants of these islands in consequence of the introduction of Christianity afford a striking and incontestible proof, that there are no tribes on the face of the earth, however barbarous and debased, but may be raised to the dignity of their moral and intellectual natures, were the religion of the Bible once introduced among them, and every other judicious means employed to promote their progress in knowledge and civilization.

The *Sandwich Islands* lie about 20 degrees north of the equator



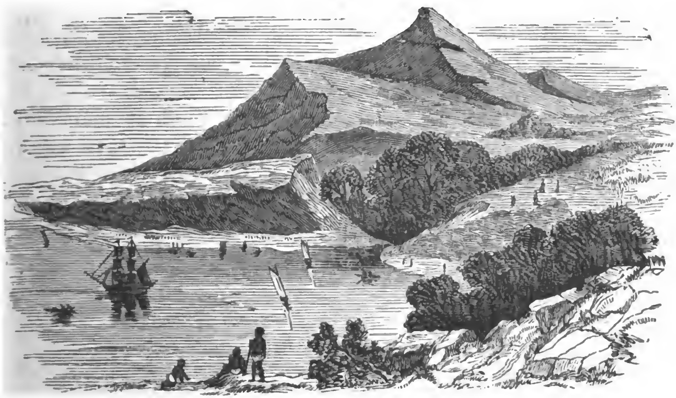
SCENE OF THE MURDER OF CAPTAIN COOK. OWHYHEE.

and about 2500 miles north by west of Tahiti. *Owhyhee*, the largest of the group, is remarkable for the murder of the celebrated Captain

Cook in 1779. It measures eighty-four miles in length, by seventy in breadth. It abounds with lofty mountains. Mount Roa rises to the height of 16,000 feet, and mount Koa to the height of 18,000 feet, the tops of both being covered with perpetual snow. It also abounds with volcanoes. The volcano of Peli, on the flank of mount Roa, is reckoned one of the most striking and awful in any part of the world. The people of the Sandwich islands have, of late years, embraced Christianity, and several missionaries from the United States are now settled in those regions. A considerable part of the population, including the king and his court, attend the schools they have established, and the ordinances of Christian worship. They have formed a small navy, and carry on a profitable trade with foreigners, and the general state of morals is undergoing a great improvement.

The *Friendly Islands* include the Fejee, and several other detached islands, of which Tongataboo is the largest. They enjoy a remarkably rich soil, which is carefully cultivated by the natives, who rank among the most respectable of the South sea islanders, and are remarkable for their neatness and skill in improving and enclosing their lands. Christianity has been introduced into some of these islands, chiefly by the persevering labours of the Wesleyan missionaries. Their population is reckoned at about 110,000.—The *Navigator's Islands* are among the most important and fertile groups yet discovered in Southern Polynesia. The natives are uncommonly tall and stout, and remarkable for a ferocity of character scarcely found in any other part of *Polynesia*. Here, however, the Christian religion has also been introduced, and is already producing many interesting and beneficent effects.—The *Marquesas* are situated north by east from the Society isles, within nine degrees of the Equator. Their inhabitants are distinguished for their fair complexion and peculiar beauty, but they are fierce and licentious in their character. Christianity has been introduced, but has hitherto produced little effect upon them.—The *New Hebrides* are a group generally covered with high mountains, some of which contain volcanoes. They are situated about 500 or 600 miles west of the Friendly isles, and were first discovered by Quiros in 1606, when they were supposed to be part of a great southern continent which philosophers then imagined to exist. But Cook, in 1774, explored the whole group, and gave them the name of the New Hebrides. The cluster consists of about seventeen islands, of

which *Terra del Espiritu Santo* is the largest. At *Erromango*, one of these islands, the deeply lamented missionary WILLIAMS was treacherously and cruelly murdered by the natives, together with another missionary of the name of HARRIS, in 1839, when attempting to introduce Christianity among them. This island will be as



SCENE OF THE MURDER OF WILLIAMS AND HARRIS. ERROMANGO.

much distinguished in future ages for this atrocious murder as the island of Owhyhee has been for the murder of Captain Cook. The geographical discoveries of this celebrated circumnavigator prepared the way for most of the missionary operations which have been undertaken in the islands of the Pacific, and of all the labourers in this work of philanthropy, none stands so conspicuous for unwearied beneficent exertions in this holy cause, and for the important and beneficial effects with which they have been accompanied, as the lamented WILLIAMS. His 'Narrative of Missionary Enterprises in the South Sea Islands' deserves to be read by every Christian, by every philosopher and statesman, and by every one who feels a delight in contemplating beneficent actions and romantic incidents.

In regard to the *human inhabitants* that occupy the different regions now specified—they have been divided by some geographers into the six following classes:—1. The dwarfish inhabitants of the polar regions; as the Laplanders, the Greenlanders, and the

Esquimaux. 2. The flat-nosed olive-coloured tawny race; as the Tartars, the Chinese, and the Japanese. 3. The blacks of Asia with European features. Of this description are the Hindoos, the Birmans, and the inhabitants of the islands in the Indian ocean. 4. The wooly-haired negroes of Africa, distinguished by their *black* colour, their flat noses, and their thick lips. 5. The copper-coloured native Americans, distinguished likewise by their black hair, small black eyes, high cheek bones, and flat noses. 6. The sixth variety is the white European nations, as the British, the French, the Italians, and the Germans.

The *number of inhabitants* that people the earth at one time may be estimated to amount to at least 840,000,000; of which 520,000,000 may be assigned to Asia; 65,000,000 to Africa; 50,000,000 to America; and 205,000,000 to Europe.—With regard to their religion, they may be estimated as follows:—

Pagans, ...	550,000,000
Mahometans, ...	160,000,000
Roman Catholics, ...	150,000,000
Protestants, ...	65,000,000
Greeks and Arminians, ...	60,000,000
Jews, ...	7,000,000
	840,000,000

From this estimate it appears that there are nearly three Pagans and Mahometans to one Christian, and only one Protestant to about fourteen of all other denominations. Although all the Roman Catholics, Greeks, and Protestants, were reckoned true Christians, there still remain more than 600,000,000 of our fellow-men ignorant of the true God, and of his will as revealed in the sacred Scriptures; which shows what a vast field of exertion still lies open to Christian benevolence, before the blessings of civilization, mental improvement, rational liberty, and Christianity, be fully communicated to the Pagan and Mahometan world.

If we suppose that the earth, at an average, has always been as populous as it is now, and that it contains 840,000,000 of inhabitants as above stated, and if we reckon thirty-two years for a generation, at the end of which period the whole human race is renewed; it will follow, that nearly 150,200,000,000 of human beings have existed on the earth since the present system of our globe com-

menced, reckoning 5846 years from Adam to the present time.[1] And consequently, if mankind had never died, there would have been nearly 184 times the present number of the earth's inhabitants now in existence. It follows from this statement, that about 25,000,000 of mankind die every year, 2853 every hour, and 47 every minute, and that at least an equal number, during these periods, are emerging from non-existence to the stage of life; so that almost every moment a rational and immortal being is ushered into the world, and another is transported to the invisible state. Whether, therefore, we contemplate the world of matter, or the world of mind, we perceive incessant changes, and revolutions going on, which are gradually carrying forward the earth and its inhabitants to some important consummation. If we suppose that before the close of time, as many human beings will be brought into existence as have already existed during the by-past ages of the world, there will of course be found at the general resurrection 296,400,000,000 of mankind. Vast as such an assemblage would be, the whole of the human beings here supposed, allowing six square feet for every individual, could be assembled within the space of about 62,400 square miles, or on a tract of land not much larger than that of England, which contains, according to the most accurate calculation, above 50,000 square miles!

Our world is capable of sustaining a much greater number of inhabitants than has ever yet existed upon it at any one time. And since we are informed in the sacred oracles that God "created it not in vain, but *formed it to be inhabited*," we have reason to believe that, in future ages, when the physical and moral energies of mankind shall be fully exerted, and when peace shall waive her olive branch over the nations, the earth will be much more populous than it has ever been, and those immense deserts where ravenous animals now roam undisturbed, will be transformed

[1] This calculation proceeds on the supposition, that only 4004 years elapsed between the creation of man and the birth of Christ, according to the Hebrew Chronology. But Dr. Hales, in his work on Scripture Chronology, has proved almost to a demonstration, that from the Creation to the birth of Christ are to be reckoned 5411 years; and this computation nearly agrees with the Samaritan and Septuagint Chronology, and with Josephus. According to this computation, 7253 years are to be reckoned from the Creation to the present time; and consequently, 220,500,000,000 of human beings will have existed since the Creation, which is more than 226 times the number of inhabitants presently existing.

into scenes of fertility and beauty. If it be admitted that the produce of twelve acres of land is sufficient to maintain a family consisting of six persons, and if we reckon only one-fourth of the surface of the globe capable of cultivation, it can be proved that the earth could afford sustenance for 16,000,000,000 of inhabitants, or about *twenty times the number* that is presently supposed to exist. So that we have no reason to fear that the world will be overstocked with inhabitants for many ages to come; or that a period may soon arrive when the increase of population will surpass the means of subsistence, as some of the disciples of Malthus have insinuated. To suppose, as some of these gentlemen seem to do, that wars and diseases, poverty and pestilence, are necessary evils, in order to prevent the increase of the human race beyond the means of subsistence which nature can afford—while the immense regions of Australia, New Guinea, Borneo, and the greater part of Africa and America are almost destitute of inhabitants—is both an insult on the dignity of human nature and a reflection on the wisdom and beneficence of divine providence. The Creator is benevolent and bountiful, and "his tender mercies are over all his works;" but man, by his tyranny, ambition, and selfishness, has counteracted the streams of divine beneficence, and introduced into the social state poverty, disorder, and misery, with all their attendant train of evils; and it is not before such demoralizing principles be in some measure eradicated, and the principles of Christian benevolence brought into active operation, that the social state of man will be greatly meliorated, and the bounties of Heaven fully enjoyed by the human race. If, in the present deranged state of the social and political world, it be found difficult in any particular country to find sustenance for its inhabitants, emigration is the obvious and natural remedy; and the rapid emigrations which are now taking place to the Cape of Good Hope, Australia, New Zealand, Van Dieman's Land, and America, are doubtless a part of those arrangements of providence by which the Creator will accomplish his designs, in peopling the desolate wastes of our globe, and promoting the progress of knowledge and of the true religion among the scattered tribes of mankind.

With that branch of knowledge to which I have now adverted, every individual of the human race ought to be in some measure

acquainted. For it is unworthy of the dignity of a rational being to stalk abroad on the surface of the earth, and enjoy the bounty of his Creator, without considering the nature and extent of his sublunary habitation, the variety of august objects it contains, the relation in which he stands to other tribes of intelligent agents, and the wonderful machinery which is in constant operation for supplying his wants, and for producing the revolutions of day and night, spring and autumn, summer and winter.—In a religious point of view, geography is a science of peculiar interest. For "the salvation of God," which Christianity unfolds, is destined to be proclaimed in every land, in order that men of all nations and kindreds and tongues may participate in its blessings. But, without exploring every region of the earth, and the numerous islands which are scattered over the surface of the ocean, and opening up a regular intercourse with the different tribes of human beings which dwell upon its surface, we can never carry into effect the purpose of God by "making known his salvation to the ends of the earth."—As God has ordained that "all flesh shall see the salvation" he has accomplished, and that human beings shall be the agents for carrying his designs into effect—so we may rest assured that he has ordained every mean requisite for accomplishing this end; and consequently, that it is his will that men should study the figure and magnitude of the earth, and all those arts by which they may be enabled to traverse and explore the different regions of land and water which compose the terraqueous globe—and that it is also his will, that every one who feels an interest in the present and eternal happiness of his fellow-men, should make himself acquainted with the result of all the discoveries in this science that have been made or may yet be made, in order to stimulate his activity in conveying to the wretched sons of Adam, wherever they may be found, "the unsearchable riches of Christ."

To the Missionary, and the Directors of Bible and Missionary Societies, a minute and comprehensive knowledge of this science, and of all the facts connected with it, is essentially requisite; without which they would often grope in the dark, and spend their money in vain, and "their labour for that which doth not profit." They must be intimately acquainted with the extensive field of operation which lies before them, and with the physical, the moral, and the political state of the different tribes to which they intend

to send the message of salvation; otherwise their exertions will be made at random, and their schemes be conducted without judgment or discrimination. To attempt to direct the movements of Missionary Societies, without an intimate knowledge of this subject, is as foolish and absurd as it would be for a land-surveyor to lay down plans for the improvement of a gentleman's estate, before he had surveyed the premises, and made himself acquainted with the objects upon them, in their various aspects, positions, and bearings. If all those who direct and support the operations of such societies were familiarly acquainted with the different fields for missionary exertions, and with the peculiar state and character of the diversified tribes of the heathen world, so far as they are known, injudicious schemes might be frustrated before they are carried into effect, and the funds of such institutions preserved from being wasted to no purpose. In this view, it is the duty of every Christian, to mark the progress and the results of the various geographical expeditions which are now going forward in quest of discoveries in connection with the moral and political movements which are presently agitating the nations: for every navigator who ploughs the ocean in search of new islands and continents, and every traveller who explores the interior of unknown countries, should be considered as so many pioneers, sent beforehand, by divine providence, to prepare the way for the labours of the missionary, and for the combined exertions of Christian benevolence.[1]

But even to every private Christian, Geography is an interesting branch of study, without some knowledge of which, his prayers and his Christian sympathies cannot be judiciously and extensively directed. We occasionally hear the ministers of religion at the

[1] On this subject the author feels great pleasure in referring his readers to a small volume, published by James Douglas, Esq. of Cavers, entitled 'Hints on Missions,'—a work which deserves the attentive perusal both of the philosopher, the politician, and the Christian, and particularly of the Directors of Missionary Societies. The following excellent works on this subject are warmly recommended to the serious attention of the reader:—1. 'The Great Commission,' by Dr. Harris, President of New College, author of 'Mammon,' etc.—a prize Essay on Christian Missions. 2. 'Missions, their authority, scope, and encouragement,' by the Rev. Richard W. Hamilton, Leeds. 3. 'The Jubilee of the World,' by the Rev. J. Macfarlane. 4. 'Christian Missions to Heathen Nations,' by the Honourable and Rev. Baptist W. Noel, M.A.

commencement of public worship on the first day of the week, imploring the Divine blessing on their brethren throughout the Christian Church who are commencing the same exercises; and at the close of worship in the afternoon, that the same blessing may seal the instructions which have been delivered in all the churches of the saints; as if all the public religious services of the universal Church were at that moment drawing to a close. This is all very well, so far as it goes: the expression of such benevolent wishes is highly becoming, and congenial to the spirit of Christianity. But a very slight acquaintance with geographical science will teach us, that when we in this country are commencing the religious services of the first day of the week, our Christian brethren in the East Indies, who live under a very different meridian, have finished theirs; those in Russia, Austria, Greece, Palestine, and on the banks of the Caspian sea, have performed one-half of their public religious worship and instructions; and those in Australia and Van Dieman's Land have retired to rest at the close of their Sabbath. On the other hand, our friends in the West India islands and in America, at the close of our worship, are only about to commence the public instructions of the Christian Sabbath. If, then, it be admitted, that our prayers, in certain cases ought to be *specific*, to have a reference to the particular cases and relations of certain classes of individuals, there can be no valid reason assigned, why they should not have a reference to the geographical positions of the different portions of the Christian church as well as to those who live on or near our own meridian: that, for example, in the beginning of our public devotions, we might implore that the blessing of God might accompany the instructions which have been delivered in the Eastern parts of the world; and at the close of worship, that the same agency might direct the exercises of those in the Western hemisphere, who are about to enter on the sacred services of that day. On the same principle we may perceive the absurdity of those "*concerts*" for praying in different places *at the same hour*, which were some time since proposed, and attempted by a certain portion of the religious world. Even within the limits of Europe this could not be attempted with the prospect of Christians joining in devotion at one and the same time; for when it is six o'clock in one part of Europe, it is eight in another, and five o'clock at a third place; and much less could such a concert take place throughout Europe, Asia, and America. So

that science, and a calm consideration of the nature and relation of things, may teach us to preserve our devotional fervour and zeal within the bounds of reason and propriety; and, at the same time, to direct our reflections and our Christian sympathies, to take a wider range than that to which they are usually confined.

Besides the consideration now suggested, a serious contemplation of the physical objects and movements which this science exhibits, has a tendency to excite pious and reverential emotions. To contemplate this huge globe of land and water, flying with rapidity through the voids of space, conveying its vast population from one region to another, at a rate of 1,500,000 miles in a day, and whirling round its own axis at the same time, to produce the constant succession of day and night,—to contemplate the lofty ridges of mountains that stretch around it in every direction; the flaming volcanoes; the roaring cataracts; the numerous rivers, incessantly rolling their watery treasures into the seas; the majestic ocean and its unfathomable caverns; the vapours rising from its surface, and replenishing the springs and rivers; the avalanche hurling down the mountain's side with a noise like thunder; the luxuriant plains of the torrid zone; the rugged cliffs and icebergs of the polar regions; and thousands of other objects of diversified beauty and sublimity,—has an evident tendency to expand the conceptions of the human mind, to increase its sources of rational enjoyment, and to elevate the affections to that all-powerful Being who gave birth to all the sublimities of Nature, and who incessantly superintends all its movements.

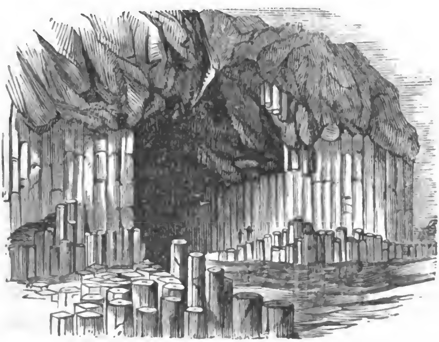
In fine, from the numerous *moral* facts which Geography unfolds, we learn the vast depth and extent of that moral degradation into which the human race has fallen—the ferocious tempers and immoral practices which are displayed in the regions of Pagan idolatry—the horrid cruelties and vile abominations that are daily perpetrated under the sanction of what is termed Religion—the wide extent of population over which the prince of darkness sways his sceptre—the difficulties which require to be surmounted, before "the Gospel of salvation" can extend its full influence throughout the Pagan world—and the vast energies which are requisite to accomplish this glorious event. All these portions of information are calculated to confirm and illustrate the scriptural doctrine of the universal depravity of man—to exercise the faith of the Christian on the promises of Jehovah, in reference to the conversion of

the benighted nations—to rouse his sympathies towards his degraded brethren of mankind, to excite his intercession in their behalf, and to direct his benevolence and activity, in devising and executing schemes for enlightening the people who are sitting "in darkness, and in the shadow of death."

Geology.

Another subject intimately related to the former is the science of Geology.

This science has for its object, to investigate and describe the *internal structure* of the earth, the arrangement of the materials of which it is composed, the circumstances peculiar to its original formation, the different states under which it has existed, and the various changes which it appears to have undergone since the Almighty created the substance of which it is composed. From a consideration of the vast quantity of materials contained in the internal structure of our globe, and of the limited extent to which men can carry their operations, when they attempt to penetrate into its bowels, it is obvious that our knowledge of this subject must be very shallow and imperfect. The observations, however, which have been made on the structure of our globe during the last half century, and the conclusions deduced from them, are highly interesting both to the philosopher and to the Christian. Before the facts on which this branch of Natural History is founded were accurately ascertained, various objections to the Mosaic history of the creation were started by certain sceptical philosophers,



FINGAL'S CAVE.

founded on partial and erroneous views of the real structure and economy of the earth; but it is now found, that the more accurately and minutely the system of nature is explored, the more distinctly do we perceive the harmony that subsists between the records of Revelation and the operations of the Creator in the material world If both be admitted as the effects of the agency of the same almighty and eternal Being, they must, in the nature of things, completely harmonize, and can never be repugnant to each other—whether we be capable in every instance of perceiving their complete coincidence or not. If any facts could be produced in the visible creation which directly contradict the records of the Bible, it would form a proof, that the oracles which we hold as divine were not dictated by the Creator and Governor of the universe. But although some garbled facts have been triumphantly exhibited in this view, it is now ascertained, from the discoveries which have been lately made in relation to the structure and formation of the earth, that the truth of the facts detailed in Sacred History rests on a solid and immutable basis; and that the Supreme Intelligence who arranged the fabric of heaven and earth, and he alone, communicated to the inspired writers the doctrines and facts they have recorded; and we have reason to believe, that as Geologists proceed in their researches and investigations, still more sensible proofs of the authenticity of Revelation will be brought to light.

Geology has become an interesting object of inquiry to the student of general science, and is now prosecuted with ardour by many distinguished philosophers. The observations which have been made in various parts of the world by late navigators; the facts which have been ascertained by Pallas, Saussure, De Luc, Humboldt, Lyal, Sedgwick, Ansted, Tennant, and other intelligent travellers and philosophers; and the discoveries which have been brought to light by modern chemists and mineralogists, have all conspired to facilitate Geological inquiries, to render them more enlightened and satisfactory, and to prepare the way for future ages establishing a rational, scriptural, and substantial theory of the earth. The man who engages in such inquires has always at hand a source of rational investigation and enjoyment. The ground on which he treads—the aspect of the surrounding country—the mines, the caves, and the quarries which he explores—every new country in which he travels, every mountain he climbs, and every new surface of the earth that is laid open to his inspection, offer to him novel and interesting stores of information. On descend-

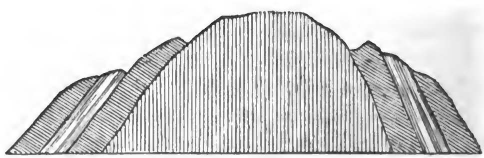
ing into mines, we are not only gratified by displays of human ingenuity, but we also acquire views of the strata of the earth, and of the revolutions it has undergone since the period of its first formation. Our researches on the surface of the earth, amidst abrupt precipices and lofty mountains, introduce us to the grandest and most sublime works of the Creator, and present to our view the effects of stupendous forces, which have overturned mountains, and rent the foundations of nature. "In the midst of such scenes, the Geologist feels his mind invigorated; the magnitude of the appearances before him extinguishes all the little and contracted notions he may have formed in the closet; and he learns, that it is only by visiting and studying those stupendous works that he can form an adequate conception of the great relations of the crust of the globe, and of its mode of formation."[1]

At first sight, the solid mass of the earth appears to be a confused assemblage of rocky masses, piled on each other without regularity or order, where none of those admirable displays of skill and contrivance are to be observed, which so powerfully excite attention in the structure of animals and vegetables. But on a nearer and more intimate view, a variety of beautiful arrangements has been traced by the industry of Geologists, and the light of modern discoveries: by which they have been enabled to classify these apparent irregularities of nature. The rocks of which the crust of the earth is chiefly composed, occur in beds or layers, each of which is distinguished by its peculiar characteristic. 1. The first class is what has been denominated Primary Rocks. These constitute the great framework or primitive envelope of the globe. They form the most lofty mountains, and at the same time extend downwards below all the other formations to the greatest depths yet penetrated by man, and constitute every where the foundation on which the other rocks are supported. It is therefore supposed that they were the earliest formed, in the progress of creation; and are hence denominated *primitive* or *primary* rocks. One of the principal rocks of this class is *granite*, which is compounded of *quartz*, *felspar*, and *mica*. *Gneis*, or slaty granite, is considered as another species; and *mica slate* a third species of the primitive rocks. There are some other primary rocks which occur embedded in and interstratified with the principal primitive rocks. They are called *subordinate rocks*, and are named as follows:—*Horne-*

[1] Edinburgh Encyclopædia. Art.— Mineralogy.'

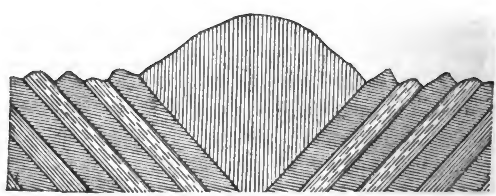
blende rock, *Serpentine, Crystalline, Limestone, Quartz* rock. The three principal rocks of this class, granite, gneis, and mica slate, might with propriety be regarded as belonging to one formation. They are composed *essentially* of the same minerals, varying in different proportions, and are rather modes of the same rock than different species. They pass by gradations into each other, as one or other of their constituent minerals becomes more or less abundant; they alternate with each other in various situations, and may be regarded as contemporaneous.—Granite is considered as the foundation rock, on which slate and all secondary rocks are laid. When granite rises above the surface, the beds of other rocks in the same district rise towards it, and lie against it, as in fig. 1;

FIG. 1.



but there are instances in which they appear to pitch under the granite, as in fig. 2. The aspect of granite mountains is extremely various. When the beds are horizontal, or when the rock is soft and disintegrating, the summits are rounded and unpicturesque. (See fig. 2.) When hard and soft granite occur in the

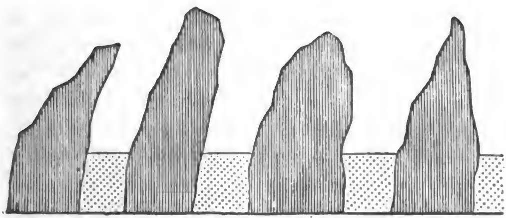
FIG. 2.



same mass, the soft decomposes, and leaves the hard in large loose masses upon the soil, or if they lie in alternate and highly inclined

beds, the hard granite forms high and almost inaccessible peaks, as seen in fig. 3.

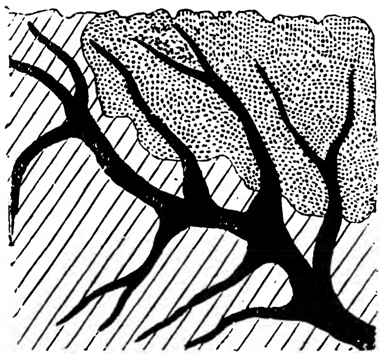
FIG. 3.



The structure of primary rocks is *crystalline* (see fig. 3.) they form the central parts of the most elevated mountain chains—they never contain the fragments of other rocks—and they are particularly distinguished from all the other formations in this,—that *they contain no remains of organized substances.* There also appears conclusive evidence that materials composing granite, of which this class of rocks chiefly consist, were once in a state of fusion.

2. The class of rocks next in order to the primitive are what are termed TRANSITION ROCKS,—which are next and above the primitive on which they rest. This formation is composed of the larger fragments of all the primitive rocks consolidated into continuous masses. It is supposed that these rocks were formed, when the primary rocks were thrown up from the bed of the primeval ocean, when the disruptions caused by such powerful and mighty movements reduced the higher parts of the primitive to fragments. These shattered fragments becoming agglutinated by their own pulverent cement, recomposed continuous strata which form the rocks to which we allude. In this class of rocks we first behold the rudiments of vitality—the dawn of organization—the first-born of earthly creatures, whose existence is recorded in imperishable characters. These consist of organized beings of the lowest orders, such as sea shells of various descriptions, which are here found embedded, and which afford a decisive evidence that such rocks were formed *after* the creation of organized beings.—

The rocks belonging to this class are *Transition* or mountain limestone — *Graywacke*, and graywacke slate—*Slate* and its varieties. Roof-slate, and the slate of which school slates are made, are well known varieties of this rock. It is sometimes called *clay-slate*, argillaceous slate, and argillaceous schist. Transition rocks are the principal repositories of metallic ores, which occur both in beds and veins more abundantly in many of the rocks of this class than in primary rocks.



A METAL VEIN IN TRANSITION ROCKS.

3. The next class is the SECONDARY ROCKS, which lie upon the transition rocks, and appear like deposits composed of grains which once belonged to primitive rocks. Geologists now divide these rocks into *upper* secondary and *lower* secondary. The principal secondary formations are: (1.)—The *coal* formation, in the lower secondary series, and the rock-salt or saliferous formation in the upper secondary. The strata of the coal formation are numerous, extensive, and parallel; but they are often beset, undulating, curved, broken, and contorted in various ways. The strata connected with the coal bear evidences, in some instances, of having been rapidly deposited, as in the cases where we find the vertical stems of plants standing in their natural position, in many coal mines, and the rocks deposited around them in horizontal or slightly inclined strata. The stems of aborescent plants, two or three feet in diameter, are thus found piercing through the strata many feet. In such a case, the sand mud must have been deposited within a comparatively short time around them, otherwise in a climate such as that in which these plants grew, they would have decayed and left no indications of their existence.—Coal occurs in regular strata which vary in thickness from a few inches to several feet or yards. In the same coal formations many strata of coal occur under each other separated by strata of shale, sandstone, etc. The series of strata which occur together is called a *coal field.*

Coal fields are of limited extent, and the strata often dip to a common centre, being often arranged in basin-shaped cavities, which appear to have been originally detached lakes that were gradually filled up by repeated depositions of carbonaceous and mineral matter. The different strata over and under the beds of coal are frequently similar, and the same series of strata is repeated for each successive stratum of coal, as shown in fig. 4.

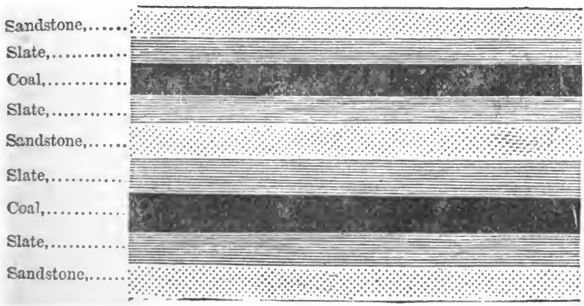


Fig. 4.—COAL FORMATION.

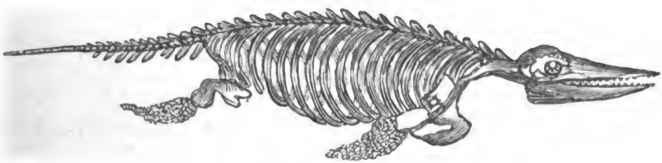
Coals are generally supposed to have had a *vegetable* origin; and, when we consider the abundance of vegetable remains usually found in connection with coal, and the vegetable structure which the coal itself sometimes exhibits, we can hardly doubt as to its origin. At most coal mines, even the thinnest layers of slate, when split off, show the impressions of the leaves and flat stems of the various grasses, reeds, and ferns, in all their most delicate parts. The impressions between the layers of slate sometimes give as perfect a representation of the plant as if the plant had been pressed and dried in a book, and the leaves then opened to display it.—Coal is largely distributed all over the world. It is found in great quantities in the northern parts of our own island, in France, Germany, Russia, Sweden, Spain, India, Australia, both continents of America, and in the various islands of the Pacific. Its existence in the interior of Africa has not yet been determined by geologists. It would appear that wherever God has left the surface of the earth in an unpicturesque condition he has gathered together mineral treasures beneath it; for it is an almost invariable

rule that coal countries are flat, tame, and unfertile. Of the uses of coal it is hardly necessary to speak; for to it we owe not only much of our in-door comfort, but in the present state of the arts we could hardly do without it. Deprived of coal, our railways would be almost useless, and we should no longer be able to bridge the seas with that swiftness and safety which seems to set at nought the fury of the winds and waves, and to make the most distant parts of the world neighbours to each other. Without coal the ores of iron, and lead, and copper, and silver, and gold, might be neglected in the dark bowels of the earth; and the steam-engine—that great worker and diffuser of the blessings of civilization—would no longer be heard in the mines and workshops of the world. The annual consumption of coal in Great Britain is about three and a-half millions of tons, and we export nearly four millions more; and yet, even at this rate of waste, it is reckoned that the supply in this island alone will last for three thousand years!

FOSSIL PLANTS FOUND IN COAL.

(2.) The *upper* secondary rocks comprise all the different formations above the great coal formations, to the upper limit of the chalk series. These rocks are divided into the three following formations. 1. *Chalk*, or cretaceous rocks, including the ferruginous and green sand. 2. *Oolitic Rocks*, lias limestone, and lias clay. 3. *Red Sandstone*, including magnesian limestone.—The red sandstone

formation is characterized by the first appearance of the remains of the *Saurian*, or lizard-shaped animals. The remains of a number of species have been found, differing in their appearance from

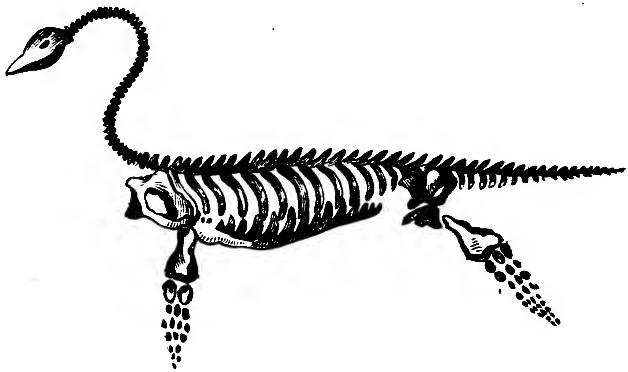


THE TCHTHYOSAURUS FROM THE LIAS FORMATION.

the crocodile and alligator, some of which must have been from 60 to 120 feet in length. These animals appear to have lived in salt water, unlike any of this class with which we are acquainted at the present day, all of which belong either to the land or to fresh water. They had neither feet nor fins, but paddles like the sea turtle, and their tails were long, of the form of an oar, and fitted to propel them through the most agitated waters. The *Ooolitic* rocks are composed of various strata of limestone, clay, sand, and sandstone. *Ooolite* (gr. *oon*, an egg, and *lithos*, stone) derives its name from the small egg-like globules that are embedded in this species of rock—some of the masses of which appear composed of little rounded globules like the *roes* of fish. These rocks are remarkable for the great variety of organic remains they contain. The animal remains are those belonging to the land and to fresh water. The teeth and bones of fish and reptiles are abundant. The reptiles are mostly *saurian* animals and turtles. Among these are the Megalo saurus, the Plesio saurus, and the Iguanodon, some of which must have been at least 70 feet in length, and of the height of an elephant. There are also *vegetable* fossils in these rocks, consisting of aborescent forms, trunks of palms, gigantic reeds, and similar vegetable productions, which are now to be found growing only in the Torrid Zone.

4. The next division is the Tertiary, which is considered as having been deposited after the Secondary. The strata comprehended under this class consist of beds of clay, marl, sand, pudding stones, and imperfectly consolidated limestone, which appear to have been deposited since the chalk formation. The tertiary de-

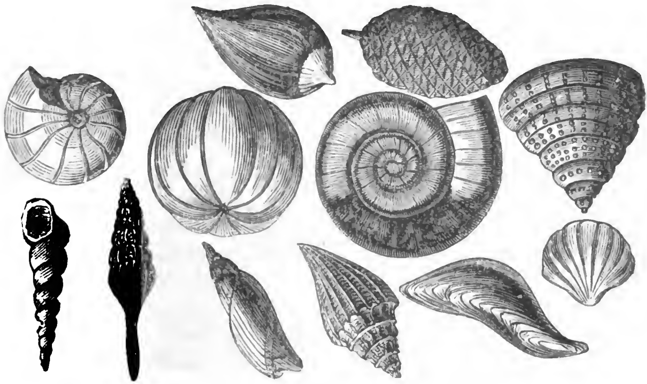
posits contain no beds of minerals or metallic veins, capable of exploration, except lignite and jet, which are used for fuel and



THE PLESIOSAURUS FROM THE LIAS FORMATION.

ornament,—clay for pottery, sand for manufacture of glass, pyrites for the manufacture of copperas and alum, and a valuable iron ore called hydrate of iron. This formation, however, abounds with a vast quantity of vegetable and animal remains, such as crocodiles, crabs, lobsters, several species of vertebral fish, and a vast number of testaceous exuviæ; so well preserved as to have the appearance of recent shells. The most remarkable discovery that has been made respecting the Tertiary deposits is, that many of them contain the bones of *mammiferous animals* (that is those which suckle their young) as perfect in their organization as any of the existing species of land animals; but most of them belong to genera or species that are extinct. These strata are further remarkable for presenting the frequent alternation of beds containing the remains of marine animals, with other beds that contain the bones of land animals, or fresh water shells. The city of Paris, in France, and the country around, which are situated upon a tertiary deposit, which rests upon chalk—are remarkable for the extraordinary organic remains which they contain. Millions of marine shells compose the principal mass. Bones of marine animals, of which the genera are entirely unknown, are found in certain parts

Other bones, remarkable for their vast size, and of which some of similar genera exist only in distant countries, are found scattered

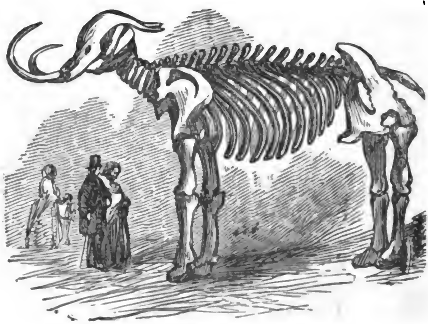


SHELLS AND SEEDS FROM THE TERTIARY FORMATION.

in the upper beds. Not only the remains of sea animals and land quadrupeds, but also those of birds, are found in this deposit, such as the duck, the pelican, the woodcock, the starling, and the sky-lark. The famous locality of fossil fish at Monte Bolca in Italy, is in tertiary strata. About 105 species have been found in those quarries, and many of them are different from any species known to exist in the neighbouring seas, or even in any part of the earth.

5. The next distinction of formations made by Geologists is Diluvial and *Alluvial* deposits—the former being generally considered as having been formed by the last general deluge, and the latter by currents of rivers and other causes now in operation The blocks of rocks and the beds of gravel spread or scattered on the surface of the ground, composed of stone or fragments foreign to the district in which they are spread, and which frequently cover the bones of unknown species of qudrupeds—are called *Diluvial* depositions, that is, depositions which have been caused by a deluge. The materials of these deposits are usually coarse, and composed of gravel, pebbles, and blocks of a great variety of rocks aggregated without any regularity. The sand, soil, or frag-

ments brought down by rivers, and spread along their banks or at their mouth, are called *alluvial* depositions. The bones and skeletons of large animals, are found in diluvial gravel in many countries. In Siberia and America, the tusks of fossil elephants are found in the diluvial banks of almost every river, and sometimes in such abundance, that the ivory from their skeletons is an article of export.

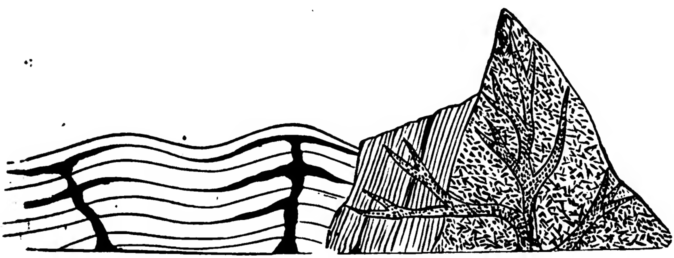


ELEPHAS ANTIQUUS, OR MAMMOTH.

ALLUVIAL deposits are the most superficial of all the formations; they are forming every day; they envelope the remains of animals that still exist on the surfaces they have formed, and they are also mingled with the remains of animals which have existed in recent times. The alluvial beds taken as masses are all of loose earth, and are never covered by rocky masses; and in these beds chiefly are to be found the remains of human beings and the monuments of their industry and art. There is a constant tendency in torrents, currents, rivers, tides, winds, and similar causes, to wear down the inequalities of the land and to deposit the materials in the sea. In this way *deltas*, such as those of the Nile, the Ganges, the Missisipi, the Danube, and the Rhone, have been formed. The mouths of the Mississipi are now more than 100 miles from that river's original entrance into the gulf of Mexico, and for hundreds of miles most of the land seen from its banks is alluvial; so that all the mass of land alluded to has been formed by alluvial depositions carried down by the rapid current of this mighty river. The delta of the Ganges commences 220 miles in a direct line from the ocean; and the town of Adria, which was once a port on the Adriatic and a station for a Roman fleet, is now, from the sea having receded, more than twenty miles inland.

6. There is likewise a species of Rocks distinguished by Geolo-

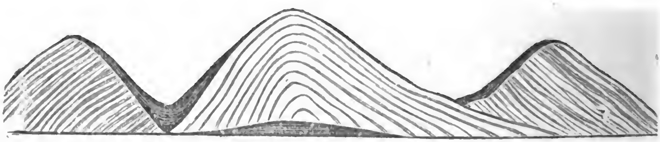
gists by the title of VOLCANIC and BASALTIC rocks; which owe their origin to volcanic fire, and are sometimes forced up to the surface of the earth by the action of subterranean heat. The principal volcanic rocks are *basalt*, *lava*, and *greenstone*. Volcanic rocks occur in shapeless masses, and are destitute of organic remains. In some parts of Europe, as in Iceland, Sicily, and the country around Naples, active volcanoes still exist, which frequently emit vast quantities of lava, ashes, and other species of matter. But even in places where no active volcanoes exist, as in Avergne, Velay, and Vivavais, in France, several hundreds of conical hills are found, with craters near their summits. These hills are composed of materials similar to those of active volcanoes, and streams of lava may sometimes be traced proceeding from the cones into the adjoining valleys, where they choke up the ancient channels of rivers, in the same manner as some of the modern lavas in Iceland have been known to do, the rivers either flowing beneath, or



HORIZONTAL STRATA PENETRATED BY TRAP ROCKS: GRANITE PENETRATED BY MORE RECENT GRANITE VEINS.

cutting out a passage on one side of the lava.—TRAP rocks are related to volcanic, and are mostly composed of horneblende and felspar. The term *trap* is derived from the German word *trappa*, a stair, as many of these rocks occur in a terrace form, or like the steps of a stair—a configuration which is supposed to be owing to the stopping of large sheets of lava when flowing, whether at the bottom of the sea or on dry land; for it is known that streams of lava generally terminate in abrupt precipices, similar to the beds constituting the trap ranges. These rocks are dis-

tinguished, even at a distance, from those of the stratified formations, as they occur in shapeless masses, and form hilly tracts of great irregularity of surface, or in the form of walls or *dykes*



TRAP ROCK UPLIFTING SUPERINCUMBENT STRATA.

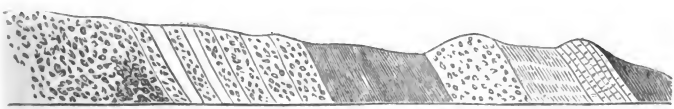
penetrating other rocks, which they alter in character to a certain degree at this point of contact.

Basalt is of a black or bluish-grey colour. It is commonly fine-grained, and consists of an intimate admixture of felspar and augite, a variety of horneblende, with some oxyde of iron. Many of the western islands of Scotland are wholly or almost composed of basalt. The island of *Staffa* is a complete mass of basalt. It is about two miles in circumference, and is surrounded on every side by steep cliffs, seventy feet high, formed of clusters of angular columns, containing from five to seven sides each. Fingal's cave is in the S.E corner of the island, and presents a magnificent chasm forty-two feet wide, and two hundred and twenty-seven in length. The roof, which is one hundred feet high at the entrance, gradually diminishes to fifty, and is composed of the projecting extremities of basaltic pillars, and the base of a causeway of the same materials.—The *Giant's Causeway,* in the county of Antrim, in Ireland, is another striking specimen of basaltic columns. It consists of hundreds of thousands of five and six sided columns, varying from one to five feet in thickness, and from twenty to two hundred feet in height. The district in which this remarkable formation occurs lies on both sides of the river Bann, and comprehends an area of 800 square miles. Throughout this area, the basalt is found occupying all the eminences, and constituting an overlying bed of igneous rocks, at least 500 feet in thickness. The greatest mass of basalt yet known occurs in the province of Deccan in India, where it constitutes the surface over an area of many thousand square miles.

Organic remains are not found promiscuously scattered through

the several systems of rocks, but each formation has its peculiar group of animals and plants; and on comparing together the larger groups of strata, we find but few organic remains common to any two of them. These fossil animals and plants are found together in groups, very much as living plants and animals are—different groups occupying different portions of the surface of the earth and of the ocean. Hence it is concluded, that these remains were once living plants and animals, which, in different periods, occupied the ocean and the dry land, grouped together as we now find them, and that, as they died, they became enveloped in rock, near the places where they passed their existence.

Some of the formations and deposits to which we have alluded particularly the *Mountain limestone*, consist almost entirely of the shells and coralline productions of sea animals, and this formation is often 1000 or more feet in thickness, and many miles in length and breadth. In what are termed the *Silurian* formations is found



SECTION OF THE SILURIAN SYSTEM.

a long succession of strata many thousand feet thick, and embedding not fewer than five hundred species belonging to the animal kingdom.

It is considered an established fact, that of more than 3000 species of plants and animals that are found in a fossil state in the secondary rocks, not a single species corresponds with any now living on the globe; and even out of 3000 fossil species in the Tertiary formation less than 600 are identical with living species. In short, in all the different formations, till we come to the uppermost and the newest, the thousand species they contain are all different from any in the now existing creation though possessing family analogies.

It is a remarkable fact that notwithstanding the great variety of fossils observed in the early formations, the remains of *man* are not to be found in these formations. The remains of human be-

ings and the vestiges of the arts and operations of man are discovered only in or upon those earthly masses which are demonstrably posterior to all regular geological deposits—or, the Diluvial and Alluvial formations—and under circumstances indicating the human species to have been among the recent productions of the Creator's power, and that man was created at a period posterior to those great changes and convulsions which destroyed so many millions of animated beings. Had this not been the case, remains of the human species would have as certainly been found in the early formations as those of reptiles, fishes, and quadrupeds.

"The phenomena of Geology show that the original formation of the rocks has been accompanied, in nearly all its stages, by a process of waste, decay, and recomposition. The rocks as they were successively deposited were acted upon by air and water, heat, etc., broken into fragments or worn down into grains out of which new strata were formed. Even the newer secondary rocks, since their consolidation, have been subject to great changes, of which very distinct monuments remain. Thus, we have single mountains, which from their structure can be considered only as remnants of great formations, or of great continents no longer in existence. Mount Meisner in Hesse, six miles long, and three broad, rises about 1800 feet above its base, and 2100 above the sea, overtopping all the neighbouring hills for forty or fifty miles round. The lowest part of the mountain consists of the same shell, limestone, and sandstone which exist in the adjacent country. Above these are, first, a bed of sand, then a bed of fossil wood 100 feet thick at some points, and the whole is covered by a mass of bassalt, 500 feet in height. On considering these facts, it is impossible to avoid concluding, that this mountain, which now overtops the neighbouring country, occupied at one time the bottom of a cavity in the midst of higher lands. The vast mass of fossil wood could not all have grown there, but must have been transported by water from a more elevated surface, and lodged in what was then a hollow. The bassalt which covers the wood must also have flowed in a current from a higher side; but the soil over which the bassalt and the wood passed has been swept away, leaving this mountain as a solitary memorial to attest its existence. Thus also on the side of mount Jura, next the Alps where no other mountain interposes, there are found vast blocks of granite at the

height of more than 2000 feet above the lake of Geneva. These blocks are foreign to the rocks among which they lie, and have evidently come from the opposite chain of the Alps; but the land which constituted the inclined plane over which they were rolled or transported has been worn away, and the valley of Lower Switzerland, with its lakes, now occupies its place. Transported masses of primitive rocks of the same description are found scattered over the north of Germany, which Von Buch ascertained, by their characters, to belong to the mountains of Scandinavia; and which therefore carry us back to a period when an elevated continent, occupying the basin of the Baltic, connected Saxony and Norway.[1]

The production of a bed for *vegetation* is effected by the decomposition of rocks. This decomposition is effected by the expansion of water in pores or the fissures of rocks, by heat or congelation, by the solvent power of moisture, and by electricity, which is known to be a powerful agent of decomposition. As soon as the rock begins to be softened, the seeds of *lichens*, which are constantly floating in the air, make it their resting place. Their generations occupy it till a finely divided earth is formed, which becomes capable of supporting mosses and heath; acted upon by light and heat, these plants imbibe the dew and convert constituent parts of the air into nourishment. Their death and decay afford food for a more perfect species of vegetable; and at length a mould is formed, in which even the trees of the forest can fix their roots, and which is capable of rewarding the labours of the cultivator. The decomposition of rock tends to the *renovation* of soils, as well as their cultivation. Finely divided matter is carried by rivers from the higher districts to the low countries, and alluvial lands are usually extremely fertile. By these operations the quantity of habitual surface is constantly increased; precipitous cliffs are gradually made gentle slopes, lakes are filled up, and islands are formed at the mouths of great rivers; so that as the world grows older, its capacity for containing an increased number of inhabitants is gradually enlarging.

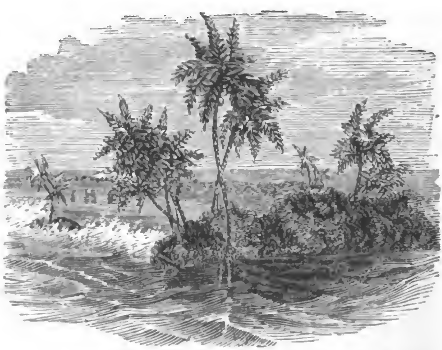
Coral Islands.—In connexion with what has been now stated, I may here introduce a brief description of coral islands—a subject which has excited the admiration not only of the geologist and

[1] Supplement to Encyclopædia Brittannica, 6th edit., vol. vi.

the philosopher, but has formed an interesting theme for one of the most elegant of our modern poets.

"I saw the living pile ascend,
The mausoleum of its architects
Still dying upwards as their labours closed.
Slime the material, but the slime was turned
To adamant by their petrific touch.
Frail were their frames, ephemeral their lives,
Their masonary imperishable. All
Life's needful functions, food, exertions, rest,
By nice economy of Providence,
Were overruled to carry on the process
Which out of water brought forth solid rock.
Atom by atom, thus the mountain grew,
A coral island, stretching east and west.
——Compared with this amazing edifice,
Raised by the weakest creature in existence,
What are the works of intellectual man,
His temples, palaces, and sepulchres?
Dust in the balance, atoms in the gale,
Compared with these achievements in the deep,
Were all the monuments of olden time.
——The Pyramids would be mere pinnacles,
The giant statues wrought from rocks of granite
But puny ornaments for such a pile
As this stupendous mound of catacombs,
Filled with dry mummies of the builder-worms."[1]

These coral islands it is now ascertained, have been formed by the operations of a minute animal belonging to the species of *polypi*. Before proceeding to a description of the islands, it will be proper to give some account of the animals from which they derive their formation.

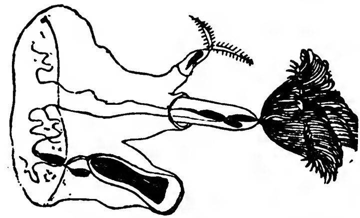


CORAL ISLAND AND REEF.

There are many varieties of the polypus; which term is derived from two Greek words meaning many feet. Some species inhabit

1 Montgomery's Pelican Island.

fresh water, and others are peculiar to the ocean; but one leading principle pervades the whole. Whoever looks with care into the bottom of a wet ditch, when the water is stagnant and the sun has been powerful, may see many little transparent lumps of jelly, about the size of a pea, and flattened on each side; and if we examine

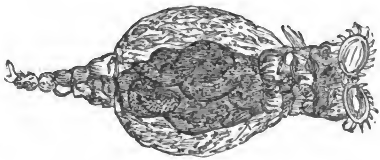


FRESH WATER POLYPUS.

the under side of the broad-leaved weeds that grow on the surface of the water, we shall see them studded with a number of these jelly-like substances, which are no other than living polypi gathered up into a quiescent state; and seemingly inanimate, because either undisturbed or not excited to action by the calls of appetite. When they are seen exerting themselves, they put on a very different appearance. In order to conceive a just idea of their figure, we may suppose the finger of a glove cut off at the bottom, we may suppose also several threads or horns planted round the edge like a fringe. The hollow of this finger will give us an idea of the stomach of the animal; the threads issuing forth from the edges may be considered as the arms or feelers with which it hunts its prey. The animal at its greatest extent is seldom seen above an inch and a half long, but it is much shorter when contracted and at rest. It is furnished neither with muscles nor rings, and its manner of lengthening and contracting itself resembles more that of the snail than worms or any other insect. The arms, where the animal is not disturbed, are thrown about in various directions in order to seize and entangle its prey; sometimes three or four of the arms are thus employed, while the rest are contracted, like the horns of a snail, within the animal's body.

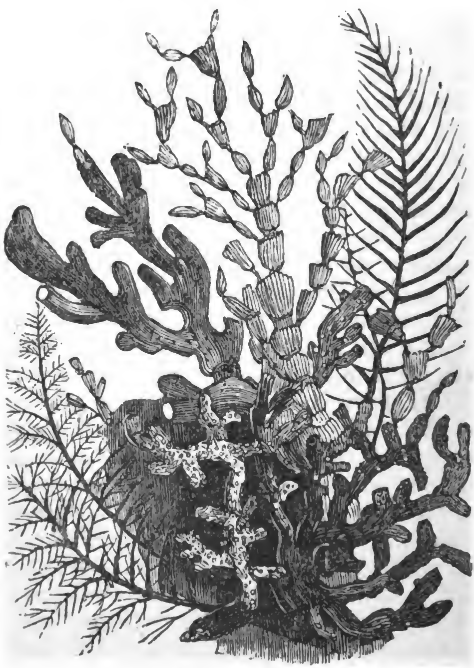
This is the common polypus, but the coral insect belongs to the sea polypi, which I will endeavour to describe. Let us imagine a a short hollow cylinder of animal matter, apparently gelatinous. Within this there is a solid substance, from the extremity of which proceed numerous active fibres, or *tentacula*, forming a kind of crown like the stamina of a flower. These are the arms or feet. The polypus which forms the cells of certain coral, is further pro-

vided with a circle of hands surrounding the cylinder. Those in the *madrapore* are equal in number to the divisions of the cell which they form; each arm or hand being a *bifid*, and embracing a lamina of that cell. There is another species called *vorticella*, the simplest of which resembles in shape a child's top, and is com-



VORTICELLA MAGNIFIED 10,000 TIMES.

monly very minute, and sometimes almost microscopical. From the base of the cone or top of the animal there proceeds a crown of tentacula, as in the polypus, serving the same purpose of seizing the prey and conveying it to the body, which is its stomach. This simple species is independent and free to move wherever it pleases, and its movements, are extremely active. In the next stage we find the vorticella attached to a rock, or to some other solid, by a root, and limited in its wanderings by the length of the stem. Proceeding further, we find a number of



FORMATION OF CORAL.

those united, by various stems or branches, to a common root; and

in this case the whole structure resembles a vegetable, the root producing a stem and branches, and each branch terminating by that conical animal, which thus emulates the flower of the mimic plant. It appears that whatever nourishment any of these receives is appropriated to the nutrition of the whole, and they all agree together to move the whole body in any one direction. Each animal is a simple oval gelatinous body; and when separate, as it often is, swims, by taking in water at one end of a tube which passes through the body, and emitting it at the other. When united in a chain, as they sometimes are, they all act together as if by one volition. But the most important aspect presented by these animals is their power of constructing for themselves a habitation of stone.

Many polypi, such as those now described, co-operating by a regular design, produce a common structure, which in some instances puts on the tree-like shape so well known in the white coral of the museums. Each animal constructs its own immediate house or cell, to which it is inseparably attached, while the whole, co-operating, produce the connecting medium, whether stony or soft, by which the colony is united. The exact mode in which these animals are propagated is unknown; the period of the existence of any one individual seems very limited; yet, in certain cases, the republic itself may be considered as unchangeable and perpetual. As the stony structure is completed, the first animals die; new ones are produced on the new shoots which themselves form, and thus the work incessantly goes on. Insignificant as these animals may appear, they produce wonderful effects, and hold an important place in the system of nature. Their powers, compared with their apparent minuteness and insignificance, are wonderful and little short of miraculous.

Certain species of the coral zoophites known as polypi are to be found in nearly all climates, but they abound chiefly in the regions within the tropics. In size they vary from the size of a pin's head, or even less, to somewhat more than the bulk of a pea; and it is to the persevering efforts of creatures so insignificant, working in myriads, and working throughout ages, that the enormous structures which pass under the denomination of CORAL ISLANDS owed their existence. In the south Pacific ocean, the coral islands are formed by the coral polypi now described. Their works commence at the bottom of the sea, and they are gradually erected till their structures reach the surface. Sometimes they work in straight or

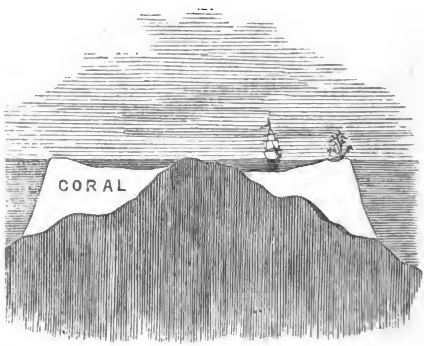
slightly curved lines, which are determined by the form of the submarine surface. On these they form mountain ridges, such as the great reef of Australia, which extends for several hundreds of miles. On other occasions they work in circles or ovals; and it is in this way that most of the islands and groups have been formed. On one side they are perpendicular, so that a ship strikes in a moment from deep soundings; on another they shelve, and thus a circular reef gradually fills towards the middle, but generally so as to have a vacuity in the centre. When the animal has reached the surface of the water, it can work no higher, and thus the vertical height of the living reef can be no greater than the difference between high and low water at low tides. When the reef is dry at low water, the coral animals cease to increase. A continuous mass of solid stone is then seen, which is composed of shells and echini, with fragments of corals, united by calcareous sand, produced by the pulverization of the shells of friable polyparia. Fragments of coral limestone are thrown up by the waves; these are cracked by the heat of the sun, washed to pieces by the surge, and drifted on the reef. After this the calcareous mass is undisturbed, and offers to the seeds of the cocoa, pundanus, and other trees and plants, floated thither by the waves, or brought from neighbouring shores by birds; a soil on which they rapidly grow, and overshadow the white, dazzling surface. Trunks of trees, drifted from other shores find here a resting place, and on these are brought many small animals, such as lizards, shell-fish, and insects. Even before the trees form groves or forests, sea birds nestle there; strayed land birds find refuge in the bushes; and at a still later period, man takes possession of the newly created land. It is in this way that the Polynesian archipelago has been formed. The immediate foundation of the islands are ancient coral reefs, and these, in all probability, are based on the cones or craters of submarine volcanoes long since extinct. There is another circumstance worthy of remark. Most of these islands have an inlet through the reef opposite to the large valleys of the neighbouring land whence numerous streams issue and flow into the sea; an easy ingress is thus afforded to vessels, as well as the means of obtaining a supply of water.

The Pacific ocean throughout a space comprehended between the 30th parallel of latitude on each side of the equator, is extremely productive of coral. The Arabian gulf is rapidly filling

with this substance, and it is said also to abound in the Persian gulf. Between the coast of Malabar, and that of Madagascar, there is also a great sea of coral. An unbroken reef is described by Captain Flinders, on the east coast of Australia, 350 miles in length; and between that country and New Guinea, captain King found the coral formations to extend throughout a distance of 700 miles, interrupted by no intervals exceeding thirty miles in length. The chain of coral reefs and islets called the Maldives, situated in the Indian ocean to the south west of Malabar, form a chain 480 geographical miles in length, running due north and south. It is composed throughout of a series of circular assemblages of islets, the larger groups being from forty to fifty miles in their longest diameter.—The Laccadive islands run in the same line with the Maldives, on the north, as do the isles of the Chagos archipelago on the south; so that these may be continuations of the same chain of submarine mountains, crested in a similar manner by coral limestones. Possibly they may all be the summits of volcanoes; for if Java and Sumatra were submerged, they would give rise to a somewhat similar shape in the bottom of the sea; since the volcanoes of those islands observe a linear direction, and are often separated from each other by intervals corresponding to the stolls of the Maldives; and as they rise to various heights, from five to ten thousand feet above their base, they might leave an unfathomable ocean in the intermediate spaces.

These islands vary in extent, as well as in the degree of finish they have received. Of thirty two of these examined by captain Beechey, the largest was thirty miles in diameter, and the smallest somewhat less than a mile. They were of various shapes, and all formed of living coral except one, called Henderson's Island, which was partially surrounded by it; and they all appeared to be increasing in size by the active operations of the zoophites, which are actively extending and building up above the level of the sea those parts which are at present below the water. Twenty-nine of the number had *lagoons*, or morasses, in their centres, within which, it has been observed, the smaller species of coral seek a quiet abode, and labour silently and slowly, in throwing up banks which, in process of time, unite with islets which surround them, and at length fill up the lagoon, so that what was at first a ring of little islands becomes one connected mass of land. All these islands are situated within the action of the trade wind, and fol-

low one general rule in having their windward side higher, and more prominent than the other, and not unfrequently well-wooded, while the other is only a half-drowned reef, or wholly under water. One of these islands presents the singular appearance of perpendicular coral reefs, elevated eighty feet above the level of the sea: these were of dead coral, but the outside of the island was surrounded with a belt of living coral sloping from the cliffs to from three to twenty-five fathoms under water, after which it descends abruptly to a depth where a 200 fathom line does not reach the bottom. The surface of this island is flat, and it is not easy to account for its present elevation, unless by an earthquake, or submarine volcanic explosion.



SECTION OF A LAGOON ISLAND.

The principal groups of islands of coral formation, besides those now mentioned are those which lie from the New Hebrides, eastward,—the Friendly islands, Navigator's islands, and the Society islands; and to the northward of the Society isles the Marquesas. These groups are separated from each other by channels or seas, wider than those which separate the individual islands which form the respective groups; but all these waters abound with shoals and minor islets, which indicate the existence of a common base, and show that the processes by which they will hereafter be united above the level of the sea are in constant operation.

As the coral animals do not erect their fabrics, above the level of the sea, we must suppose that the operations already described are continually going forward, before the islands they rear be fit for being the habitations of man.

As to the *rapidity* with which the coral insects advance in the formation of their structures, we are not yet in possession of a sufficient number of facts, so as to form a definite conclusion. The

following facts, however, may lead us to form some rude conceptions on this subject. The island of *Osnaburgh* was supposed to be only a reef of rocks when the Matilda was wrecked there in 1792. It is now an island fourteen miles in length, and covered on one side with tall trees, and the lagoon in the centre is dotted with columns. The coral therefore has made a rapid progress since 1792, although Captain Beechey found two anchors of a ton weight each, which he supposed belonged to the Matilda, thrown upon the sunken reef of live coral, and around these anchors the coral had made no progress in growing, while some large shell fish, adhering to the same rock, were so overgrown with coral, as to have only space enough left to open about an inch. It is probable, however, that the oxide proceeding from the anchors may have heen prejudicial, so far as its effects extended, to the coral insect, and thus have prevented its growth. —All navigators who have visited the Pacific declare that maps and charts are of no use after a few years, owing to the number of fresh rocks and reefs which are continually rising to the surface, and it is perfectly accordant with the instinct of animals to continue working without intermission, until their labours are consummated, or their lives extinct.

It is a fact worthy of remark, that on all these islands, a plentiful supply of fresh and sweet water may be obtained, by digging three or four feet into the coral; and that even within one yard of high water mark such a supply is to be found. This is an important consideration to the navigators of those seas, where such a resource is so valuable, on account of the extreme heat to which they are exposed; and it shows also the powerful properties of the coral, in divesting the water of its saline particles. These properties, which are probably *chemical*, and not merely the effect of filtration, have never been examined or experimented upon; but they furnish a subject of consideration for the naturalist and the man of science.

General Remarks and Reflections on this Subject.—From the general facts now stated we may learn that there are wonderful processes and transformations going forward in the system of nature of which we have at present but a very imperfect conception. Who could have imagined, till of late, that in the deepest recesses of the ocean, there should be a process going forward, on an extensive scale, for the purpose of rearing large

islands, and vast continents, to be the seats of vegetation, and the abodes of man and other tribes of animated existence? Under any circumstances which we could have previously conceived, such a process would have appeared most singular and almost incredible. But when we find that process carried rapidly forward by the meanest and apparently the most insignificant agency that could possibly be employed—by an animal formerly supposed to belong to the vegetable tribes—by an insect barely possessing life, and whose dimensions are less than those of a house fly—we are overwhelmed with feelings of wonder and astonishment. Yet the whole of the Pacific ocean is studded with islands reared by the architecture of these small and insignificant insects. An animal tied down to its narrow cell, ephemeral in its existence, and scarcely appearing to possess volition—is founding new islands and continents, constructing, as it were, the materials of a new world, and creating habitations for plants and animals and millions of human beings who may arise to people them in the future ages of the world. These are the wonders of the mighty hand of Him "who stretched out the heavens and laid the foundations of the earth," and they show us from what simple principles and apparently insignificant agencies the most grand and astonishing effects may be produced when guided by the hand and intelligence of that Being "who is great in counsel and mighty in operation."

It has been a question, and a question which we cannot yet resolve, whence proceeds all the rock and calcareous earth of which coral islands are composed; for all corals consist of calcareous earth —of lime united by animal matter? The whole appears to be the creation of the animal, while itself is a soft substance. It is probably a secretion from its organs; but from what source or in what manner is this secretion produced? We are completely ignorant on this point, and man with all his chemical discoveries and investigations is still unable to explain the facts to which we allude. Yet it is supposed, on good grounds, that all the limestone to be found in the world has been the production of animals, either shell fish, coral polypi, or similar acquatic tribes. Thus, however, it is that by means on which our boasted philosophy might have been disposed to look down with scorn, Nature, in the hand of the Almighty, accomplishes some of her most noble and sublime operations.

In the next place, from the facts stated, we may learn, that the habitable surface of the globe is gradually enlarging, and that there is no reason to fear that for many centuries to come, the world will be overstocked with inhabitants. Malthus and his disciples, some years ago, endeavoured to alarm us with an idea that population would increase to such an extent as to surpass the means of subsistence. If ever such an event were to happen, it could only be after the lapse of numerous ages. But while we view the world as under the government of a wise and benevolent Being, we can never suppose that such an event shall ever take place. He who at first breathed into man the breath of life, and gave existence to all the inferior tribes of animals, can never be supposed to leave them destitute of the means of existence at any future period of duration. As the earth now stands, the quantity of habitable land upon its surface is sufficient to maintain a population of at least *fifty times* the number of that which now exists, were all its desolate wastes brought into a state of cultivation; and this is possible to be effected, were mankind to act in harmony and union, and to devote those energies which have hitherto been employed in war and devastation, to the purposes of physical and mental improvement. But, before the earth as it now stands could be filled with inhabitants, at the present rate of increase, numerous islands or continents will have sprung up from the depths of the ocean—the work of the puny animal to which we have been adverting—capable of supporting, perhaps, hundreds of millions of human inhabitants. At present, the dry land is little more than one-fourth of the area of our globe, but in the course of a few centuries, when all the coral islands now forming in the Pacific and Indian oceans shall be completed, a habitable surface may be presented to view equal in extent to the whole of Asia, or even the whole of the Eastern continent; and if the process now going forward shall still continue in their progress, nearly three-fourths of the surface of our globe may be transformed into habitable lands where myriads of the human race, and other animated beings, may in future ages find happiness, and enjoy the bounties of their Beneficent Creator.

In short, from the facts and processes adverted to above, we may learn how foolish and absurd it is for nations to engage in ruinous and destructive wars for the acquisition of territory. The greater part of the globe is still a scene of desolation; but were it

cultivated to the extent of which it is capable, it would be amply sufficient to afford subsistence for twenty times its present population.[1] Why, then, all this bustle of war and contention, and running the risk of destroying the commerce, wealth, and the happiness of nations, to secure the possession of an uncultivated desert, which cannot yet be peopled. The United States of America have more territory than they can occupy for centuries to come, and yet they seem disposed to run the risk of destroying their national resources, and having thousands of their citizens and children slaughtered, for the chance of acquiring power over adjoining territories and low distant islands which they can neither people nor cultivate—a species of MADNESS altogether inconsistent with the character of any nation that denominates itself civilized and Christian. The Creator has hitherto afforded ample room and provisions for all the creatures that now exist on our globe; and when its desolate wastes shall be peopled and cultivated, he is preparing, by the agency of myriads of insignificant insects, vast territories for the abode and comfort of succeeding generations.

Of all the memorials of the past history of our globe, the most interesting are those myriads of remains of organized bodies which exist in the interior of its outer crusts. In these we find traces of innumerable orders of beings existing under different circumstances, succeeding one another at distant epochs, and varying through multiplied changes of form. "If we examine the secondary rocks, beginning with the most ancient, the first organic remains which present themselves are those of aquatic plants and large reeds, but of species different from ours. To these succeed madrepores, encrenites, and other aquatic zoophytes, living beings of the simplest forms, which remain attached to one spot, and partake, in some degree, of the nature of vegetables. Posterior to these are ammonites, and other mollusci, still very simple in their forms, and entirely different from any animals now known. After these, some fishes appear; and plants, consisting of bamboos and ferns, increase, but still different from those which exist. In the next period, along with an increasing number of extinct species of shells and fishes, we meet with amphibious and viviparous quadrupeds, such as crocodiles and tortoises, and some reptiles, as serpents, which show that dry land now existed. As we approach the newest of the solid rock formation, we find lamantins, phocæ,

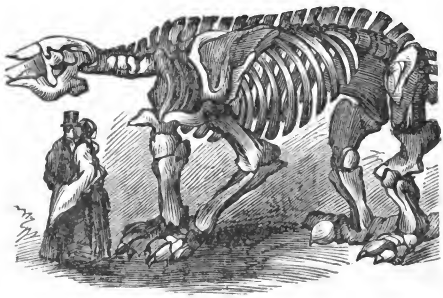
[1] See Article Geography.

and other cetaceous and mammiferous sea animals, with some birds. And in the newest of these formations, we find the remains of herbiferous land animals of extinct species, the paleotherium, anaplotherium, etc., and of birds, with some fresh water shells. In the lowest beds of loose soil, and in peat bogs, are found the remains of the elephant, rhinoceros, hippopotamus, elk, etc., of different species from those which now exist, but belonging to the same genera. Lastly, the bones of the species which are apparently the same with those now existing alive, are never found except in the very latest alluvial depositions, or those which are either formed in the sides of rivers, the bottom of ancient lakes and marshes now dried up, in peat beds, in the fissures and caverns of certain rocks, or at small depths below the present surface, in places where they may have been overwhelmed by debris, or even buried by man. Human bones are never found except among those of animal species now living, and in situations which show that they have been, comparatively speaking, recently deposited."[1]

Numerous species of animals have been found embedded in the secondary strata—no living examples of which are now to be found in any quarter of the globe. Among the most remarkable of these are the following:—1. The *Mammoth*, which bears a certain resemblance to the elephant, but is much larger, and differs considerably in the size and form of the tusks, jaws, and grinders. The fossil remains of this animal are more abundant in Siberia than in other countries; there being scarcely a spot, from the river Don to Kamtschatka, in which they have not been found. Not only single bones and perfect skeletons of this animal are frequently to be met with; but, in a late instance, the whole animal was found preserved in ice. This animal was discovered on the banks of the frozen ocean, near the mouth of the river Jena, in 1799; and in 1805, Mr. Adams got it conveyed over a space of 7000 miles to Petersburg, where it is deposited in the museum. The flesh, skin, and hair, were completely preserved, and even the eyes were entire. It was provided with a long mane, and the body was covered with hair. The hair was of different qualities. There were stiff black bristles from twelve to fifteen inches long, and these belonged to the tail, mane, and ears. Other bristles were from nine to ten inches long, and of a brown colour; and besides

[1] Supp. to Encyc. Brit. vol. vi.

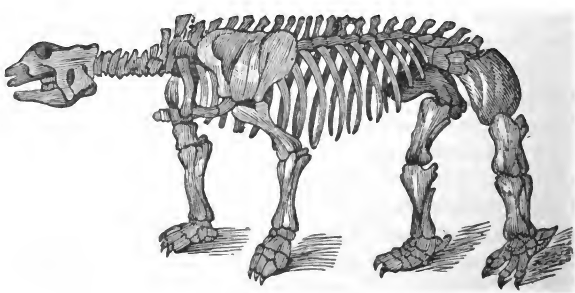
these, there was a coarse wool, from four to five inches long, of a pale yellow colour. This mammoth was a male; it measured nine feet four inches in height, and was sixteen feet four inches long, without including the tusks. The tusks, measuring, along the curve, are nine feet six inches; and the two together weigh 360 lbs. avoirdupois. The head alone without the tusks weighs 414 lbs. avoirdupois. The remains of this animal have been found likewise in Iceland, Norway, Scotland, England, and in many places through the continent onward to the Arctic ocean.



THE MEGATHERIUM.

2. The *Megatherium.* A complete skeleton of this colossal species was found in the diluvial soil near Buenos Ayres, and sent to Madrid. The specimen is fourteen feet long, and seven Spanish feet in height.

3. The Great *Mastodon* of the Ohio, of which is given a representation. This species appears to have been as tall as the elephant, but with longer and thicker limbs. It had tusks like the elephant,

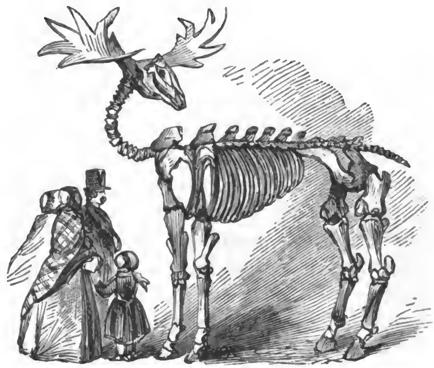


THE MASTODON.

and appears to have lived on roots. Its remains abound in America, particularly on the banks of the Ohio.

4. The *Tapir* which also abounds in America. The one named *Gigantic Tapir* is about 18 feet long, and 12 feet high.

5. The *Irish Elk*, or Elk of the Isle of Man. This gigantic species, now apparently extinct, occurs in a fossil state in Ireland, Isle of Man, England, Germany, and France. The most perfect specimen of this species, which was found in the Isle of Man, may be seen in the museum of the University of Edinburgh. It is six feet high, nine feet long, and in height, to the tip of the right horn, nine feet seven and a half inches.[1]



THE IRISH ELK, CERUUS GIGANTEUS.

Such are a few of the facts which the researches of modern Geology have disclosed. Let us now consider what are the conclusions which have been deduced from them.

One of the grand conclusions which has been deduced by modern geologists—even by those who acknowledge the divinity of the Christian Revelation, is, that *the materials of which our globe is composed are of very high antiquity*, and were brought into existence long before the race of Adam was placed upon the earth. The exact period of years which any of these materials may have existed, or any approximation to it, no geologist has yet undertaken to determine, nor is it likely that the problem will ever be satisfactorily solved. In reference to some of the coal strata, Mr. Macculloch, in his "System of Geology," states that it would be even too short a period "were we to allow 200,000 years for the

[1] The head and antlers of a Gigantic Elk, found near Douglas, Isle of Man, is in the possession of Mrs. C. Gelling, of that town.

production of the coal mines of Newcastle with all its rocky strata," not including the subsequent formations up to the present condition of the earth. Mr. Maclaren, in his 'Geology of Fife and the Lothians,' estimates a single period of volcanic quiescence, during which strata of coal, shale, sandstone, and limestone, were deposited over the side of Arthur's Seat, a basaltic hill in the vicinity of Edinburgh—at 500,000 years. Mr. Babbage, when referring to the tertiary class of formations, regards it as a truth, supported by irresistible evidence, "that the formation even of those strata which are nearest the surface, must have occupied vast periods, probably *millions* of years."[1] The Rev. Professor Sedgwick, when adverting to the process of forming deposits, says, that "a section of a few perpendicular feet indicates *a very long* lapse of time," so that in such processes "many thousands of years sink into a trifling period." In short, the most respectable modern geologists, when alluding to this point, use such expressions as the following—"immense periods of time"—"a duration to which we dare not assign a boundary"—"undefined ages"—"a long succession of monuments, for the production of each of which there may have been required 1000 ages"—"successions of events, where the language of nature signifies millions of years"—"a duration which it would be presumptuous to put into an estimate of years and centuries"—with many other expressions of a similar import. Whether such strong and unlimited expressions be warranted by the nature of the processes alluded to, I do not take upon me to determine.

2. Another conclusion which has been deduced from the above facts, is, that during the changes which the globe has undergone, since its original production out of nothing, *several destructions and subsequent new creations of animals and plants have taken place*, perhaps at very different and very distant epochs. The majority of geologists conclude, that four or five distant epochs of destruction and renewal may be traced in the organic remains contained in the different strata; in other words, that whole groups have been swept at once from existence by some powerful catastrophe, and their places supplied by other races, called into existence by the creating energy of the Almighty. The records of geology seem to testify that such was the condition of the globe, in those early periods, as to temperature and other circumstances, that our pre-

[1] Babbage's Ninth Bridgewater Treatise.

sent race of animals could not have then existed, and that such was the nature and constitution of these primeval beings, that they could not exist in the present constitution and circumstances of our globe; their natures being adapted to the different conditions of the earth, at different periods of its existence.

3. A third conclusion is, that *the successive changes to which our globe has been subjected, have been improvements in its condition as a habitable world,* that there has been a correspondent advance towards perfection in the natures of the animals and plants which have been placed upon its surface; and that *the Deity, during this long period of successive changes, was gradually fitting up this world for the ultimate residence of moral and intellectual beings,* such as the human species that now inhabit it. For it appears next to certain that the race of man could not have inhabited this globe in any of the past periods of its duration, prior to that era in which he was placed upon it. It would appear that the Deity did not think proper to prepare a suitable habitation for man by a *miracle,* or a direct interposition of his almighty energy, but by the agency of those physical laws which he had impressed upon the elementary principles of the material universe. And in order that matter might not exist in vain, myriads of beings were brought into existence, under the direction of Infinite Wisdom, endowed with faculties and natures adapted to those peculiar states of the terraqueous globe in which they were to pass their existence.

Such are a few of the facts connected with the constitution of our globe, and the conclusions which have been deduced from them. It now remains that we inquire into their accordance with the records of the Sacred history.

It has been too frequently taken for granted by theologians and commentators, that the whole system of the material universe was brought into existence within the period of 6000 years from the present time; and hence, some of them who have been anxious to reconcile the Mosaic and the Geological chronologies, have attempted to show that all the formations and changes in the strata of the earth, to which we have alluded, might have been effected within the period of 6000 years, and particularly during the continuance of the deluge in the days of Noah. Some of them have insinuated that the *coralline reefs,* which exhibit vast accumulations of calcareous matters, and which abound on the coasts of Australia,

and among the islands of the Pacific ocean, have been all formed since the present order of things commenced; and therefore that all the other formations to which we have alluded, even the oldest, may have been formed within the same period. It has also been insinuated, that it appears derogatory to the wisdom and power of the Creator to suppose, that for thousands of years the earth should have been occupied merely with vegetables and animals of the lowest orders, and that many species of each class were alternately created, and permitted to retire out of existence.

But such positions are now considered as absolutely untenable by all the most scientific and respectable geologists of modern times, as being inconsistent with facts that are every where perceptible in the strata of our globe. As to the designs which the Almighty had in view, in replenishing the earth for so long a period of time, chiefly with the inferior ranks of existence, and again permitting them to perish, it becomes us to speak with reverence and humility, as beings whose faculties are limited, and altogether inadequate to trace the inscrutable paths of the Divinity, or to investigate the reasons of every part of his procedure. We cannot, in many cases, decide as to what is consistent or inconsistent with the attributes of the Almighty: and, in the present case, as well as in many others, we must admit that the operations of the Deity are unsearchable, and "his ways past finding out." "Canst thou by searching find out the secrets of God? Canst thou find out the designs of the Almighty? they are as high as the heavens, deeper than Hades; the measure thereof is longer than the earth and broader than the sea." But this we know, that, in consequence of the previous revolutions which our globe had undergone, it was prepared for being a suitable habitation for the human species, and for the other ranks of animated nature that now possess it; and although some portions of it present the appearance of desolation and disarrangement, yet were man, its chief inhabitant, renovated in the spirit of his mind, and found acting on the moral principles of Christianity, in the capacity of communities and nations, it might soon be cultivated and renovated throughout all its extent, so as to present the aspect of a terrestrial paradise, and to shine forth with all the beauties of Eden.

But, to come more particularly to the subject in hand. Had Moses, in his history of the creation, positively declared that every portion of the material world was created out of nothing, within

1650 years of the period of the deluge, or about 6000 years ago, it would be difficult, if not impossible, to reconcile the facts of geology with the Mosaic history. But no such position is to be found either in the writings of Moses or throughout any other portion of sacred Scripture. For the illustration of this point, it may be proper for a little to consider the meaning and import of the 1st verse of the 1st chapter of Genesis: *"In the beginning God created the heavens and the earth.*

This proposition is to be considered as a *Preface* to the narrative contained in the Book of Genesis, of the arrangements connected with our terrestrial system, and, indeed, to the whole of divine revelation; and a more comprehensive, emphatic, and *appropriate* introduction can scarcely be conceived. By *the heavens and the earth,* we are undoubtedly to understand the whole frame of the material universe, with all the bodies it contains, whether existing throughout immensity—whether suns, planets, comets, nebulæ, or whatever else exists throughout the regions of boundless space. All the bodies comprehended under this general expression are here said to have been *created,* that is, brought from nothing into existence by the energy of an eternal and omnipotent agent. The original Hebrew word, ברא, *Bara,* does not indeed necessarily convey this idea, as it most frequently signifies "to produce something new or wonderful," or "to arrange, to renovate, or new-model" something which was previously in existence. It is a matter of rational inference, however, and strictly accordant with just philosophical principles, that the material universe was *created out of nothing.* It is such an inference as cannot be resisted without doing violence to the fundamental laws of human belief. This magnificent frame of the universe is here said to have been brought into existence by God, the God of Israel, the self-existent and eternal Jehovah. This declaration was intended to teach the Israelites, and all others, that the material world as to its original atoms, did not arise without a cause, or out of pre-existent materials; that the beautiful order it now exhibits did not originate from the fortuitous concourse of atoms, as some heathen philosophers imagined, and that it did not derive its existence from any of the gods of the nations, as some of their blinded worshippers foolishly imagined. In opposition to all such chimerical, absurd, and atheistical notions, Moses declares, "In the beginning God"—the God of Israel—"created the heavens and the

earth." As if he had said, That God who delivered you from the land of Egypt, after having displayed so many signs and wonders; who divided the waters of the Red sea before you, and who appeared in awful majesty on mount Sinai; that God whom you are commanded to worship, and whose laws you are bound to obey—is the great Being who reared that wonderful fabric of heaven and earth which your eyes behold.

The *period* when this astonishing effect was produced is also here declared, "*In the beginning.*" Upon a proper conception of the meaning of this expression depends, in a great measure, the reconciliation of the geological and the Mosaic chronology. The phrase here stated, "In the beginning," is used to denote the commencement of an era, or of a series of successive events. It evidently implies that, at what period soever in the long lapse of past duration, any part of the material creation was brought into existence, it derived that existence from the self-existent and eternal Divinity. But no specific period is here stated. Had Moses expressly told his readers that this period, when the first materials of creation were brought into existence, was about 2500 years from the time in which he wrote, then there would have been an almost insuperable difficulty in reconciling the discoveries of geology with such a statement. But no such assertion, either directly or by implication, is to be found throughout the whole range of divine revelation. Tens of thousands of years, or even millions of ages, may have elapsed since the first portions of matter were created, or previous to what is termed the first day's work, in the arrangements of our globe,—for any thing that Scripture asserts to the contrary. No limit is fixed to the time which may have elapsed between the period when the component materials of our globe were created, and the period when it began to be reduced into the order in which we now behold it; and no information is given as to the events which may have occurred during this interval. For it appears to have been the chief design of the sacred historian to give a narration of those events which were introductory to the placing of man upon the earth. And in this point of view it is important to remark, that the passage before us is entirely independent of the narrative of the six days' work which follows, and is to be considered simply as a general and most important truth, forming an appropriate introduction both to the following narrative and to the whole system of Revelation.

It is therefore to be regretted that certain theologians should still persist in maintaining that the whole material creation must be limited to a period within 6000 years from this date, when Scripture is silent on this point; for in so doing, they put an argument into the hands of the philosophical infidel, which it is in his power to wield against the truth and authority of Revelation.

If the propriety of the explanation now given be admitted, then it completely removes every objection against the Mosaic record derived from the supposed antiquity of the earth. Although it could be proved that some of the strata of our globe were formed millions of ages ago; although we should conceive what is neither impossible nor altogether improbable—that our globe, in another form, has been the abode, for thousands of ages, of intellectual beings analogous to man, who are now transported to another region of creation—or that it has been the habitation of numerous and diversified races both of sentient and intellectual natures, and that millions of millions of ages have rolled on since the Creator put forth his omnipotent energy, and since such stupendous revolutions commenced—neither of such views is in the least discordant with any doctrine or fact recorded in the sacred oracles. The Psalmist declares in reference to creation, when addressing the Almighty, "OF OLD hast thou laid the foundations of the earth, and the heavens are the works of thy hands;" and the apostle Paul declares, "Thou Lord, IN THE BEGINNING, hast laid the foundations of the earth." But no specific period is stated here, or in any other portion of Scripture; and the expression OF OLD is not only correspondent with what we have now stated, but seems to imply the idea of the high antiquity of the earth.

The circumstance now adverted to—that Moses specifies no definite period as the commencement of the material creation—I consider as a corroborative argument for the truth of divine revelation. Had he written at random, or from vague tradition, or had he intended merely to give play to an exuberant fancy, in describing what no uninspired mortal could ever have known—it is not likely he would have used language so cautious and appropriate, as not to have interfered with any subsequent discoveries that might be made in the constitution of the material universe. Among all the cosmogonies which have been composed by heathen writers, either from tradition or from their own fancies, there is not one which accords with the discoveries of modern times; but,

on the contrary, they all contain statements in direct opposition to facts which are known to exist in the material system. But the inspired writers were—perhaps unconscious to themselves—directed to use such language as, when rightly interpreted, would be quite consistent with all the views and discoveries that might be opened of the works of God to the latest generations.

It has been supposed by some who cannot be persuaded to admit the notion of the high antiquity of the earth, that the rocks, with all the fossil petrifactions they contain, were created just as we find them in a moment of time. "The Divine Being," they affirm, "might as easily have made matter to assume the form of a shell, a fish, a lizard, or a water-worn pebble, such as we find in these rocks, or of any other shape or structure." To all who have bestowed the least attention on the strata of the earth and their fossil remains, such statements must appear foolish and absurd in the highest degree. To use the words of professor Silliman:—"We will not inquire whether Almighty power inserted plants and animals in mineral masses, and was thus exerted in working a long series of useless miracles without design or end, and therefore incredible. The man who can believe, for example, that the Iguanodon, with his gigantic form, seventy feet in length, ten in height, and fifteen in girth, was created in the midst of consolidated sandstone, and placed down 1000 or 1200 feet from the surface of the earth, in a rock composed of ruins and fragments, and containing vegetables, shells, fish, and rolled pebbles—such a man can believe anything, with or without evidence. If there be any such persons, we must leave them to their own reflections, since they cannot be influenced by reason and sound argument; with them we can sustain no discussion, for there is no common ground on which we can meet."

But why, I would ask, should the idea of the high antiquity of the earth frighten any person from acquiescing in it, when it is not in the least repugnant to the declarations of Scripture? So far from contracting or distorting our views of the Divine perfections, it tends to expand our conceptions of the plans and operations of the Deity. If periods of duration almost too great for human powers to estimate, have been employed since the original creation of our globe, to bring it to its present state,—if vast successive revolutions, at different eras, have taken place upon its surface—if the waters of the mighty deep have at different periods over-

flowed the solid land—if the place where we now stand was once a portion of the bottom of the ocean, over which its mighty billows for ages had rolled—if subterraneous fires have at different periods raised up from the bottom of the deep those huge mountains which now lift their summits to the clouds—if lofty mountains have been sunk down many thousand feet below their ancient level, so as to form deep valleys or the bottom of the seas—if the Almighty, after creating the matter of our globe, impressed certain laws upon its elementary substances, and left these laws to operate as they now do, with only occasional interferences—if races of animated beings have occupied the globe for myriads of ages—if new races have been created at different periods and subsequently destroyed—or if numerous orders of intelligent existence may have occupied the surface of the globe ages before man was introduced to this terrestrial scene—if tremendous convulsions have shaken the firm foundations of the earth—in short, if by all the processes to which we have alluded, our globe was gradually prepared for the purposes it now fulfils, and that the Creator chose to employ these rather than the special interposition of miraculous power—such considerations tend to exhibit the power, wisdom, and benevolence of the Deity in a new point of view, and to enlarge our conceptions of the magnificent plans of Him who is "The King, eternal, immortal, and invisible," who is "wonderful in counsel and excellent in working." We are here shown that the space which has intervened between the present time and the period when man was first placed upon the globe, is but one of the units of a vast series of chronological periods which have gone before, and which stretch backwards into the abyss of immeasurable duration. It is but a single link of the great chain which stretches from the moment when matter first arose from nothing, to diversify the wilds of immensity, down to the hour which is now passing over us. And who knows but that the system of the globe with which we are presently connected may be but one link in an interminable series of events connected with other orders of intelligencies, which will be unfolded during the revolutions of a coming eternity.

The science of astronomy directs our views to regions of space which are immeasurable by mortals, and perhaps even by intelligencies of a higher order, and discloses to our sight ten thousands and millions of magnificent orbs, whose existence was not even suspected two thousand years ago. Geology directs our views to

a stupendous series of events stretching back to the ages of a past eternity. The one conducts our vision to the far distant regions of immensity—the other to the immeasurable periods of past duration; the one enlarges our conceptions of *space*, and the innumerable objects with which it is diversified; the other expands our ideas of *time*, and the revolutions which have marked its progress. But astronomy has done more than this. Like geology, it extends our views to periods of time immensely long in the flux of past duration—periods during which thousands of the luminaries of heaven have existed and displayed their radiance. Sir W. Herschel, in his remarks on the *nebulæ*, has concluded, from a variety of ingenious reasonings and observations, that those nebulæ which assume a milky light or appearance cannot be less than about 7000 times the distance of the star Sirius, or 168,000 *billions* of miles; and from other observations it is inferred that other bodies in the heavens are removed to a *much greater* distance. Now light, notwithstanding its amazing velocity of 192,000 miles in a second, would be nearly 30,000 years ere it could fly from such nebulæ to the earth. Since, therefore, it is a fact that the light of such bodies has actually been seen, and consequently that it must have been travelling at least many thousands of years before it could have reached the eyes of any of the inhabitants of our globe; it follows, that such bodies must have been brought into existence at far distant periods of past duration, otherwise they could not thus have darted their light through such vast spaces of immensity.

The discoveries of modern astronomy likewise discloses to us certain facts which lead us to the conclusion, that certain progressive operations are going forward, analogous to those which appear to have been carried forward in remote ages in relation to our globe. Had our limits permitted, we might have shown that some of the comets appear to be in an early stage of their progress towards becoming habitable worlds—that many of the nebulæ give evidence of a gradual progression towards condensation—that the appearance of new planets and stars, the disappearance of others which had long shone in the heavens, and the gradual diminution of the light of others—the changes which appear to be occasionally taking place on the surface of the sun and planets, along with other celestial phenomena—are indications that progression towards perfection and perpetual change are not peculiar to our world, but

are principles in the Creator's government pervading the wide-extended universe.

In short, progressive improvement towards perfection forms a characteristic of the plans of the Almighty, not only in the physical but also in the *moral* world. In the first instance, after the flood, the knowledge of the true God was chiefly confined to the family of Abraham; afterwards, it was disseminated among the tribes of Israel, but circumscribed within the small territory of Judea; in process of time it was partially diffused among the surrounding nations; after the Christian era it spread abroad through the greater part of the Roman empire; it has now extended its influence over most of the European nations, and over a certain portion of the tribes that inhabit Asia, Africa, and America. It is still in progress; and on the foundation of the declarations of inspired prophets, we now look forward to the period when "the glory of Jehovah shall be revealed, and when all flesh shall see it together;" when "all the ends of the world shall remember and turn to the Lord," and "when righteousness and praise shall spring forth before all nations." And the scenes of a coming eternity will doubtless display changes and revolutions far surpassing in grandeur all the events which have happened during the myriads of ages which have already passed, and which will excite the astonishment and adoration of an admiring universe.—Even in an intellectual and political point of view, the nations are making progress towards perfection. "Old things are passing away," and new scenes of improvement are gradually unfolding. The state of society in the island in which we dwell, two thousand years ago, presents nearly as great a contrast to what is now, as the chaotic state of our globe exhibited before it was reduced to the beauty and order in which we now behold it.—In short, everything we contemplate in the scene around us is progressive; the faculties of the human mind, and the corporeal powers from infancy to manhood—the growth of all the animal and vegetable races—the improvements of art, and the discoveries of science—education, civilization, and political economy—the cultivation of the earth, the mode of travelling by sea and land, and hundreds of other objects and movements demonstrate that *progression* is a law which pervades both the intellectual and the corporeal universe—and, in the future world, the expansion of the human faculties, and the progress of the mind from one scene of material and intellectual

grandeur to another, will form one portion of the happiness of renovated spirits; and as such a progression will never cease, their felicity will be of perpetual duration; for, if a finite spirit were to stop short in its excursions, or to arrive at a boundary where it could proceed no farther—from that moment its happiness would begin to diminish, and misery, to a certain extent, would infallibly ensue.

I have only to add that, whatever may be affirmed respecting the antiquity of the materials of which the earth is composed, it is admitted by every Geologist, that our globe, *as to its present state and arrangement*, has been comparatively of short duration. All the physical monuments which exist, and the progressive changes which have happened in the strata of the earth, as well as historical monuments, and the concurrent tradition of many nations, bear witness to this truth, that the first appearance of man upon the face of the globe cannot be referred to a period farther back than 5000 or 6000 years from the present time.

Had the limits assigned to the present article permitted, I might have introduced some remarks on the second verse of the 1st chapter of Genesis, "The earth was without form and void," etc., or as it has sometimes been translated—"Afterwards the earth became waste and desolate"—which expressions evidently imply that, at the period here alluded to, the substance or materials of the globe *did exist;* for we are told that the earth "*was,*" or "*had become*" desolate or waste, previous to the arrangements which are subsequently described.

How long it had continued in this state, or in any of its previous states—whether a year, a century, or thousands of years, we are not informed, nor is there any expression in Scripture which determines this, so that we are left at full liberty to carry our views on this point as far back into the ages of past duration as the facts connected with the structure of our globe may warrant, without controverting any position contained in the sacred oracles.—I might likewise have shown that the sun and stars must have been brought into existence *before* the period called the "fourth day," at which time they were appointed "to *rule* the day, and to be for signs and seasons, and for days and years"—and that the Creator, either through the medium of physical causes, or by a direct interposition of his power, produced the effects described in the sacred narrative—such as the separation of the ocean from

the dry land—in the periods of time there specified. But the proof and illustration of such positions would occupy too much space in the present work.

On the whole, the subject of Geology forms an interesting and instructive study both to the philosopher and to the Christian. When we take a survey of the august objects which diversify the surface of our globe; when we enter the wild and romantic scene of a mountainous country, or descend into the subterraneous regions of the globe, we are everywhere struck with the vestiges of operations carried on by the powers of Nature, upon a scale of prodigious magnitude, and with the exertion of forces, the stupendous nature of which astonishes and overpowers the mind. We seem as if standing on the ruins and contemplating the vestiges of a former world. We behold hills which have melted like wax at the presence of the Lord, and mountains which have been carried into the midst of the sea. We behold rocks of enormous size, which have been rent from their foundations, and rolled from one continent to another—the most solid strata of the earth bent under the action of some tremendous power, and dispersed in fragments throughout the surrounding regions. We behold the summits of lofty mountains, over which the ocean had rolled its mighty billows—confounding lands and seas in one universal devastation—transporting plants and forests from one quarter of the world to another, and spreading universal destruction among the inhabitants of the waters and the earth. Contemplating such scenes of grandeur, we perceive the force and sublimity of those descriptions of the Deity contained in the volume of inspiration. "The Lord reigneth; he is clothed with majesty; in his hand are the deep places of the earth, the strength of hills is his also. He removeth the mountains and they know not; he overturneth them in his anger; he shaketh the earth out of her place, and the pillars thereof tremble. At his presence the earth shook and trembled; the foundations also of the hills moved and were shaken. He covered the earth with the deep as with a garment, the waters stood above the mountains. At his rebuke they fled; at the voice of his thunders they hastened away."

But, amidst all the revolutions and catastrophes that have taken place in the constitution of our globe, there is the clearest evidence of an all-wise and superintending Providence directing every event. Amidst the convulsions which have rent its strata—that

have "carried hills into the midst of the seas"—and raised mountains from the bottom of the ocean—there are striking indications of Divine Benevolence in preparing our world for the comfort and accommodation its inhabitants now enjoy. The facts disclosed by geological investigation tend to enlarge our conceptions of the attributes of the Divinity, and of the sublimity of his plans and arrangements in the universe; and to demonstrate that his creating power has been repeatedly exercised during countless ages, in calling into existence numerous orders of beings, and in carrying forward his arrangements to a glorious consummation.

Astronomy.

Another science which stands in an intimate relation to religion is Astronomy.

This sublime science teaches us the magnitudes and distances of the heavenly bodies, their arrangement, their various motions and phenomena, and the laws by which their movements are regulated. It presents to our view objects the most wonderful and sublime; whether we consider the *vast magnitude* of the bodies about which it is conversant—their immense *number*—the *velocity* of their motions—the *astonishing forces* requisite to impel them in their rapid career through the regions of the sky—the *vast spaces* which surround them, and in which they perform their revolutions—the *magnificent circles* they describe—the *splendour* of their appearance—or the *important ends* they are destined to serve in the grand system of the universe. Having adverted to this subject when illustrating the Omnipotence of the Deity, I shall here simply state a few additional facts with respect to the general appearance of the heavens, the bodies which compose the planetary system, and the discoveries which have been made in the region of the stars.

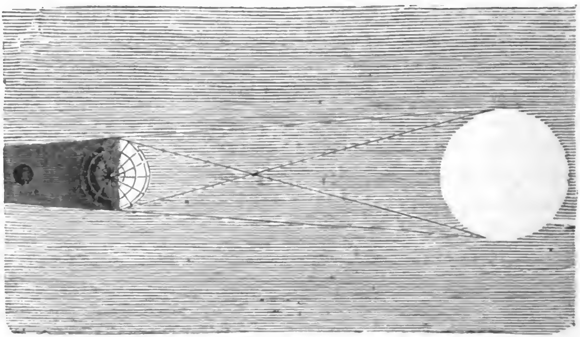
When we lift our eyes towards the sky, we perceive an apparent hollow hemisphere, placed at an indefinite distance, and surrounding the earth on every hand. In the day time, the principal object which appears in this hemisphere is the *sun*. In the morning we see him rising above the distant mountains, or from the extremity of the ocean: he gradually ascends the vault of heaven, and then declines and disappears in the opposite quarter of the sky. In the northern parts of the globe, where we reside, if, about the 21st of

March, we place ourselves in an open plain, with our face towards the south, the sun will appear to rise on our left, or due east, about six in the morning, and about the same hour in the evening he will set due west. In the month of June, he rises to our left, but somewhat behind us, in a direction towards the north-east, ascends to a greater height at noon than in the month of March, and, after describing a large arc of the heavens, sets on our right and still behind us, in the north-western quarter of the sky. In the month of December, if we stand in the same position, we may observe, without turning ourselves, both his rising and setting. He rises in the south-east, ascends to a small elevation at noon, and sets in the south-west, after having described a very small arc of the heavens. Every day he appears to move a little towards the *east*, or contrary to his apparent diurnal motion; for the stars which are seen to the eastward of him appear every succeeding day to make a nearer approach to the place in which he is seen. All the variety of these successive changes is accomplished within the period of 365 days 6 hours, in which time he appears to have made a complete revolution round the heavens from *west* to *cast*.

The *moon* is the next object in the heavens which naturally attracts our attention; and she is found to go through similar variations in the course of a month. When she first becomes visible at new moon, she appears in the western part of the heavens, in the form of a crescent, not far from the setting sun. Every night she increases in size, and removes to a greater distance from the sun, till at last she appears in the eastern part of the horizon, just as the sun disappears in the western; at which time she presents a round full-enlightened face. After this she gradually moves farther and farther eastward, and her enlightened part gradually decreases, till at last she seems to approach the sun as nearly in the east as she did in the west, and rises only a little before him in the morning, in the form of a crescent. All these different changes may be traced, by attending to her apparent positions, from time to time, with respect to the fixed stars.

A dark shadow is occasionally seen to move across the face of the moon, which obscures her light, and gives her the appearance of tarnished copper. Sometimes this shadow covers only a small portion of her surface; at other times it covers the whole of her disk for an hour or two, and its margin always appears of the figure of a segment of a circle. This phenomenon, which happens,

at an average, about twice every year, is termed an *eclipse of the moon.* It is produced by the shadow of the earth falling upon the



ECLIPSE OF THE MOON.

moon, when the sun, the earth, and the moon are nearly in a straight line; and can happen only at the time of *full moon.* Sometimes the moon appears to pass across the body of the sun; when her dark side is turned towards the earth, covering his disk either in whole or in part, and intercepting his rays from a certain portion of the earth. This is called an *eclipse of the sun,* and can happen only at the time of *new moon.* In a total eclipse of the sun, which seldom happens, the darkness is so striking that some of the planets, and sometimes the larger stars are seen, and the inferior animals appear struck with terror.

There has been no *total* eclipse of the sun visible in Great Britain since the year 1724, nor will there be one visible in our country during the present century. The first total eclipse will happen on February 3, 1916; and as few persons now living can hope to witness such an uncommon phenomenon, I shall present my readers with a few short descriptions of the appearances of nature and the effects produced on the spectators of such a scene.

In a total eclipse, which happened at Coimbra, in the year 1560, Clavius remarks, that the darkness was greater, or at least more striking than that of the night, and that the birds fell to the earth through terror. During the solar eclipse of 1699, when there was only 1-180th of the sun visible at Gripswald in Pomerania, the

obscurity was so great that the inhabitants could see neither to read nor write, and two of the planets and several of the fixed stars made their appearance. In the eclipse of 1706, which was total at Montpelier, a *corona* of pale light was observed round the moon, its breadth being about 1-12th of the moon's diameter. The same eclipse was visible at Berne in Switzerland, where the sun was totally darkened for four minutes. Before the sun began to emerge from the eclipse, a blood-red streak of light proceeded from her left limb, which continued about six or seven seconds, and then part of the sun's disk appeared, all on a sudden, brighter than Venus was ever seen in the night. The fixed stars and some of the planets appeared very bright. In all the accounts given of this eclipse, there appears to have been seen, during the continuance of total darkness, a crown or broad circle of pale light around the moon, the breadth of which was uniformly estimated at the 1-12th of the moon's diameter, which seems to indicate the existence of a lunar atmosphere.

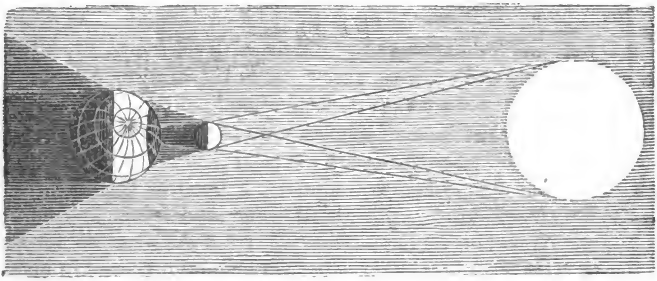
The following is an abridged account of the total eclipse of the sun which happened on the 22nd April, 1715, as given by Dr. Halley, who observed it at London. "It was universally observed," says the doctor, "that when the last part of the sun remained on the eastern side, it grew very faint, and was easily supportable to the naked eye, even through the telescope, for above a minute of time before the total darkness: whereas, on the contrary, my eye could not endure the splendour of the emerging beams in the telescope from the first moment."—"About two minutes before the total immersion, part of the sun was reduced to a very fine horn, whose extremities seemed to lose their acuteness, and to become round like stars; and for the space of a quarter of a minute, a small piece of the southern horn of the eclipse seemed to be cut off from the rest by a good interval, and appeared like an oblong star rounded at both ends, which appearance could proceed from no other cause but the inequalities of the moon's surface."—"A few seconds before the sun was totally hid, there discovered itself round the moon, a luminous ring about one-tenth part of the moon's diameter in breadth. It was of a pale whiteness, or rather pearl colour, seeming to me a little tinged with the colour of the *iris*, and to be concentric with the moon's atmosphere. Whatever this ring was, it appeared much brighter and whiter near the body of the moon than at a distance from it, and its outward circumfer-

ence, which was ill-defined, seemed terminated only by the extreme rarity of the matter of which it was composed, and in all respects, resembled the appearance of an enlightened atmosphere viewed from afar. During the whole time of the solar eclipse, I kept my telescope constantly fixed on the moon, in order to observe what might occur in this uncommon appearance, and I saw perpetual flashings or coruscations of light, which seemed for a moment to dart out from behind the moon, now here, now there, on all sides, but more especially on the western side, a little before the emersion: and about two or three seconds before it, on the same western side, when the sun was just coming out, a long and very narrow streak of a dusky but strong red light seemed to colour the dark edge of the moon, though nothing like it had been seen immediately after the immersion; but this instantly vanished upon the first appearanoe of the sun, as did also the luminous ring. As to the degree of darkness, it was such that one might have expected to have seen many more stars than were seen in London. The planets Jupiter, Mercury, and Venus, and Capella and Aldebaran among the stars, were all that were seen."—"I forbear to mention the chill and damp with which the darkness of this eclipse was attended, of which most spectators were sensible, and equally judges, or the concern that appeared in all sorts of animals, birds, beasts, and fishes, upon the extinction of the sun; since ourselves could not behold it without some sense of horror."

At Geneva, during this eclipse, Mercury, Venus, and Saturn, were seen, and to spectators on the mountains in the neighbourhood the sky appeared starry in such places as were not over-cast with clouds, in the same manner as during the night at the time of full moon. At Zurich, both planets and fixed stars were seen, the birds went to roost, the bats came out of their holes, and the fishes swam about, a sensation of cold was experienced, and the dew fell upon the grass.

The following is the latest account of a total eclipse of the sun, which happened on the 8th July, 1842. It was but partial visible in this country, but was total in the city of Vienna. All this city was in expectation for many days previous to the event, and strangers flocked to that capital in crowds on purpose to witness the phenomenon. The celebrated astronomer Schuhmacher came all the way from Denmark on purpose to see the eclipse with astronomical eyes. Soon after five in the morning, the ramparts of the

city were thronged with multitudes of spectators. About twenty minutes before six, the first spot of darkness was observed upon the sun. Soon after a perceptible degree of chillness crept into



ECLIPSE OF THE SUN.

the air, and flights of swallows flew wildly and restlessly through the darkening atmosphere. But all this gave no intimation of the effect that was to follow. But now approached the important moment. A heavy bell tolled at intervals from the city, like the funeral knell of our beautiful orb of light and life, and the sharp shrill cries of the birds, which had, however, disappeared from sight, as if to take refuge from some impending convulsion of nature. Yet a moment and on a sudden an effect took place unexpected and sublime. The whole aspect of heaven and earth underwent a change, with regard to light, shade, colouring, everything, and the instant that preceded the total eclipse resembled in nothing, and gave no idea of that which followed it. . . . Round the black sun was an irregular halo of whitish light, defining clearly and strongly the obscured orb. In some places this halo extended into longer gleams, forming altogether a faint glory like that with which painters surround the head of Christ. The rapid diminution of light, at the moment of total obscuration, was sudden and startling; also the sudden diminution of temperature, the thermometer having fallen eleven degrees instantaneously on the complete immersion of the sun. One of the most striking and unexpected effects was a red and lurid glow that suddenly kindled upon the horizon, the blue pale vapours which had risen from the east being converted into the semblance of a mighty conflagration. The

number of stars visible during this eclipse at Perpignan was ten; but the number was greater at Montpelier and Milan. Its effect upon animals was remarkable. One of the friends of M. Arago had five healthy linnets in a cage, three of which died during the sudden darkness of the eclipse. Oxen formed into a circle, with their horns thrust forward, as if to repel an enemy. At Montpelier, bats and owls appeared, sheep lay as if for the night, horses in the fields were in terror, and a swarm of ants in full march stopped short at the moment of occultation.[1]

Although total eclipses of the sun are so rare to the inhabitants of our globe, such phenomena are frequent in other planets. The eclipses of the sun, which so frequently happen to the first satellite of Jupiter, will form very interesting and impressive phenomena. Every forty-two hours this satellite suffers a solar eclipse for the space of more than two hours, and consequently, there are about eighteen eclipses every month. It is probable that it is chiefly at such times that the starry firmament appears in all its splendour to the inhabitants of this planet, and affords them an opportunity of tracing the motions of the distant bodies of the universe. To the inhabitants of our moon, solar eclipses are more frequent, and will be more solemn and impressive than with us. When a total eclipse of the *moon* happens to us, there will be a total eclipse of the *sun* to the lunarians. At that time the dark side of the earth is completely turned towards the moon, and the sun will appear gradually to pass behind the earth till it entirely disappear. And as the time of the continuance of total darkness, in central eclipses, is nearly two hours, a total eclipse of the sun will be a far more striking phenomenon to the inhabitants of the moon than solar eclipses are to us, since the continuance of total darkness, in our eclipses of the sun, is never more than four-and-a-half minutes.

On the 28th of July 1851, a partial eclipse of the sun was visible in Great Britain and the neighbouring countries.

The following is a list of the more remarkable solar eclipses which will be visible in Great Britain during the present century: —1858. March 15. 11 digits,[2] 30'.—1860. July 18. 9 digits, 12'. —1867. March 6. 8 digits, 42'.—1870. Dec. 22. 9 digits, 36'.— 1887. Aug. 19. 11 digits, 58'. This eclipse is the largest that will be visible in England during the present century, and in some

[1] Abridged from an account, from a correspondent in the *Athenæum.*

[2] A digit is the 1-12th part of the sun's diameter.

places it will be almost total. The whole surface of the sun will be covered by the moon, excepting the 1-360th part.—1912. April 17. 11 digits, 30'.—1916. Feb. 3. This a *total* eclipse, beginning at 4^h 21^m, and ending at 6^h 18^m, so that it will be only partly visible. After this period there will be no total eclipse of the sun visible here before the year 2000, or till the end of the twentieth century.

The following principles and facts may be stated in relation to eclipses:—1. The planets are all opaque bodies, illuminated by the sun, and consequently they project shadows in an opposite direction to that luminary. The earth is a body of this kind, projecting a shadow of considerable extent, and therefore the moon in passing through this shadow must be deprived of her light, or suffer an eclipse. 2. The shadow of the earth is in the figure of a cone gradually decreasing in breadth till it ends in a point at a considerable distance beyond the moon's orbit. Its breadth at the distance of the moon is at an average, about 5900 miles, and therefore is sufficient to cover the whole body of the moon for a considerable time. It is of the figure of a cone, because the earth is much smaller than the sun. If the earth were larger than the sun, the shadow would be that of an inverted cone, growing larger the farther it extended, and would eclipse the great planets, Jupiter, Saturn, and Uranus, with all their moons. 3. The moon's shadow, which causes an eclipse of the sun, is likewise conical; but as she is considerably less than the earth it extends over a part of the earth's surface only about 180 miles in diameter within which space alone, a *total* eclipse of the sun will be visible, but her *penumbra* may cover a space of 4900 miles in diameter, within the limits of which a solar eclipse will be more or less visible. 4. With regard to the number of eclipses of both luminaries, there cannot be fewer than two nor more than seven in one year; the most usual number is four, and it is rare to have more than six. 5. Lunar eclipses are visible in all parts of the earth which have the moon above the horizon, and are every where of the same magnitude and duration; but no solar eclipses are universal or seen throughout the whole hemisphere where the sun is visible. He may be totally eclipsed to one place, and partially to another, and at the same moment no eclipse will appear at a third place. 6. Eclipses of the moon begin on the left hand, or eastern limb, and end on the right hand or western limb, when viewed in our

northern latitude; but an eclipse of the sun begins on the *western* side and ends on the *eastern*. 7. When the apparent diameter of the moon is less than that of the sun, a portion of the sun's disk is projected around the body of the moon, forming a luminous ring. This is called an *Annular* eclipse of the sun. 8. There is a certain *period of eclipses*, or space of time after which the same eclipses return again. This period contains 18 years, 11 days, 7 hours, 42 minutes, 44 seconds. If therefore we add this period to the mean time of any solar or lunar eclipse, we shall have the mean time of the return of the same eclipse very nearly.

The following are some of the uses to which eclipses may be applied:—1. They afford a proof of the globular figure of the earth; for in all lunar eclipses the shadow of the earth upon the moon is always bounded by an arc very nearly circular. 2. These eclipses also prove that the sun is larger than the earth, and the earth larger than the moon. 3. They are of utility to the science of Geography, for, by means of them, we can discover the *longitudes* of places, especially by eclipses of the moon, which are most frequently visible, and which begin at the same moment of *absolute* time, at all places where they are seen. 4. They render essential service to *Chronology*, by removing doubt, respecting the dates of ancient historical events. For if a remarkable solar or lunar eclipse be recorded as having happened about the time of any memorable event, by calculation it will be found at what particular time or period the recorded eclipse happened. In one material instance the doctrine of eclipses furnishes an important correction to the era from which we reckon. It is certain that the Christian era, taken from the birth of our Saviour, ought to begin in the reign of Herod the Great, and by the testimony of Josephus an eclipse of the moon happened in Judea a few months before the death of that Herod—which eclipse is proved to have happened in the *fourth* year before the Christian era, as now adopted, in the month of March; so that there is a mistake in the accounts which have been handed down to us of this era. 5. Eclipses by being foretold, and happening at the time predicted, tend to convince the most prejudiced and unlearned, that astronomy is not a fallacious or merely conjectural science, but established on fixed and incontrovertible principles. 6. The doctrine of eclipses proves that the darkness which accompanied our Saviour's crucifixion did not arise from an ordinary eclipse of the

sun. For it happened at the Jewish passover, which was always kept at the time of full moon, at which period an eclipse of the sun could not take place according the established laws of nature. Besides, in a solar eclipse, the time of the continuation of total darkness is never more than five minutes, whereas the darkness at the crucifixion continued for more than three hours. In short, the eclipses of the sun and moon tend to arouse mankind to the study of astronomy and the wonders of the heavens, and they exhibit a striking and agreeable variety of phenomena in the scenery of the firmament, which tends to gratify the principle of curiosity implanted in the human mind.

Let us now consider the apparent motions of the starry heavens: If on a winter's evening, about six o'clock, we direct our view to the eastern quarter of the sky, we shall perceive certain stars just risen above the horizon; if we view the same stars about midnight, we shall find them at a considerable elevation in the south, having apparently moved over a space equal to one half of the whole hemisphere. On the next morning, about six o'clock, the same stars will be seen setting in the western part of the sky. If we turn our eyes toward the north, we shall perceive a similar motion in these twinkling orbs; but with this difference, that a very considerable number of them neither rise nor set, but seem to move round an immovable point, called the north pole. Near this point is placed the Pole star, which seems to have little or no apparent motion, and which, in our latitude, appears elevated a little more than half way between the northern part of our horizon and the *zenith*, or point above our heads.

Fig. 1. represents the principal stars in the constellations *Ursa Major* and *Ursa Minor*, which will enable the reader to recognize the Pole star, by attending to the following directions. The seven stars in the lower part of the figure represent Ursa Major, or the Great Bear, sometimes known by the names of the *Plough* and *Charles's Wain.* The stars on the upper part represent Ursa Minor, or the Little Bear, the largest star of which, on the right hand side, is the Pole star. About the beginning of November, at six or seven o'clock in the evening, the Great Bear will appear near the north, at a low elevation above the horizon, and nearly in the position here represented. The two stars on the right hand side of the Great Bear are called the *Pointers,* and are distant from each other about five degrees. If a line connecting these stars be

considered as prolonged upwards to a considerable distance, (about twenty-nine degrees,) till it meet the first bright star, that star is the *Pole star*, which is here represented at the higher part of the figure. Were the same observation made about the middle of April, at ten o'clock in the evening, the Great Bear will appear almost directly over our heads, *above* the Pole star, and then we must conceive the line connecting the two Pointers as drawn *downwards* towards the Pole star. At different times of the night, and at different periods of the year, the Great Bear will appear to be in different positions with respect to the Pole star, sometimes below, sometimes above, and at other times to the east or the west of it. But in all positions, a line drawn through the Pointers will always direct the eye to the Pole star.

A person who has directed his attention to the heavens for the first time, after having made such observations, will naturally enquire—Whence come those stars which begin to appear in the east? Whither have those gone which have disappeared in the west? and, What becomes, during the day, of the stars which are seen in the night? It will soon occur to a rational observer, who is convinced of the roundness of the earth, that the stars which rise above the eastern horizon come from another hemisphere, which we are apt to imagine below us, and, when they set, return to that hemisphere again; and that the reason why the stars are not seen in the day time, is not because they are absent from our hemisphere, or have ceased to shine, but because their light is obscured by the more vivid splendour of the sun.[1] From such observations we

[1] This is put beyond all doubt by the invention of the telescope; by which instrument, adapted to an equatorial motion, we are enabled to see many of the stars even at noon-day. The author of this work, in 1812 and 1813, made a number of observations by means of an *Equatorial Telescope*, to determine the following particulars:—What stars and planets may be conveniently seen in the day-time, when the sun is above the horizon?—what degrees of magnifying power are requisite for distinguishing them?—how near their conjunction with the sun they may be seen?—and, whether the diminution of the aperture of the telescope, or the increase of magnifying power, conduces most to render a star or planet visible in day-light? The results of several hundreds of observations on these points, accompanied with some original deductions and remarks, are inserted in Nicholson's Philosophical Journal, for October 1813, vol. xxxvi, pp. 109–128. The following are some of the results which were deduced from the observations:—That a star of the *first* magnitude may be distinguished, at any time of the day, with a magnifying power of thirty times, but that a higher magnifying power is preferable—That most of the stars of the

FIG. 1.—CONSTELLATIONS URSA MAJOR AND URSA MINOR, WITH DELINEATION OF THE POLE STAR.

FIG. 2.—V E N U S.

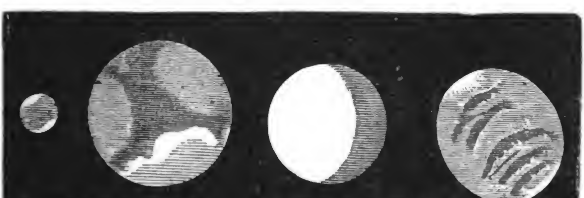


FIG. 3.—M A R S.

are led to conclude that the globe on which we tread is suspended in empty space—is surrounded on all sides by the celestial vault—and that the whole sphere of the heavens has an *apparent* motion round the earth every twenty-four hours. Whether this motion be real, or only apparent, must be determined by other considerations.

Such general views of the nocturnal heavens, which every common observer may take, have a tendency to expand the mind, and to elevate it to the contemplation of an invisible power by which

second magnitude may be seen with a power of one hundred; and with a power of sixty times, when the sun is not much more than two hours above the horizon—That the planet Jupiter, when not within thirty or forty degrees of the sun, may be seen with a power of fifteen times; and that Venus may, in most instances, be seen with a power of from seven to one hundred times, and upwards—That Jupiter can scarcely be distinguished in the day-time, when within twenty-six degrees of the sun; but that Venus may be distinctly perceived near her superior conjunction, when only one degree twenty-seven minutes from the sun's margin; and consequently may be visible at the time of that conjunction, when her geocentric latitude equals or exceeds one degree, forty-three minutes—That she may be perceived like a fine slender crescent, within thirty-five hours after passing her *inferior* conjunction, etc. One practical purpose to which such observations on Venus, at the time of her *superior* conjunction, may be applied, is to determine the difference (if any) between her polar and equatorial diameters. For it is only at that conjunction that she presents to the earth a full enlightened hemisphere; and in no other position can the measure of both diameters be taken, except when she makes a *transit* across the sun's disk. As the earth, Mars, Jupiter, and Saturn, are found to be spheroids, it is highly probable that Venus is of a similar figure; but this point has never yet been ascertained by actual observation. See also The Edinburgh Philosophical Journal, No. V, for July 1820, p. 191; and No. XIII, for July 1822—The Scots Magazine, for Feb. 1814, p. 84—Monthly Magazine, Feb. 1814, and August 1820, p. 62 — Brewster's Ferguson's Astronomy, 2nd edition, vol. ii, p. 111.—On March 10, 1842, the author saw Venus about twelve o'clock noon, when only one degree, twenty-one minutes distant from the sun's eastern limb, with a three and a half feet achromatic telescope, magnifying ninety-five times—the aperture of the object glass being constructed to one and a half inches. And on the 2nd of Oct. 1843—the day of this planet's superior conjunction with the sun—he saw Venus, within a few minutes of the time of its conjunction, when it was only fifty-eight minutes, or less than one degree from the sun's margin. It appeared round and pretty distinct, though partly immersed in the solar rays. This is the first recorded observation of Venus having been seen at the time of its superior conjunction, and it tends to prove that the surface of Venus reflects the solar rays with peculiar brilliancy, more than that of any other planet.—For a more particular account of this observation, see 'Edinburgh New Philosophical Journal' for January 1844.

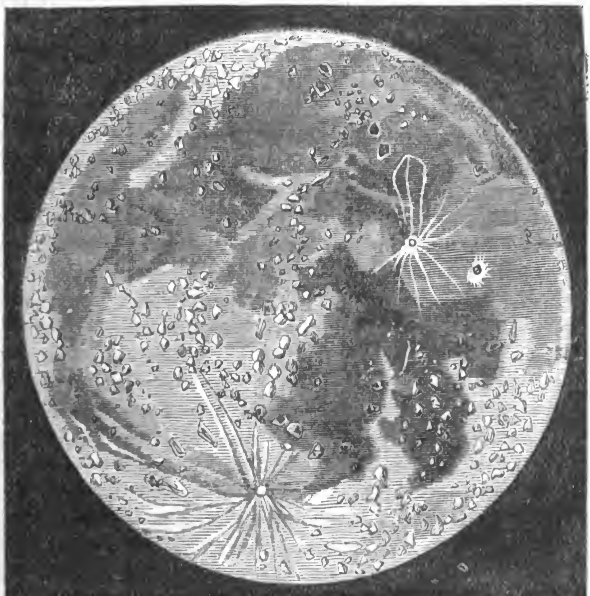
such mighty movements are conducted. Whether we consider the vast concave, with all its radiant orbs, moving in majestic grandeur around our globe, or the earth itself whirling round its inhabitants in an opposite direction—an idea of sublimity and of almighty energy irresistibly forces itself upon the mind, which throws completely into the shade the mightiest efforts of human power. The most powerful mechanical engines that were ever constructed by the agency of man can scarcely afford us the least assistance in forming a conception of that incomprehensible Power which, with unceasing energy, communicates motion to revolving worlds. And yet, such is the apathy with which the heavens are viewed by the greater part of mankind, that there are thousands who have occasionally gazed at the stars for the space of fifty years who are still ignorant of the fact that they perform an *apparent* diurnal revolution round our globe.

Again, if we contemplate the heavens with some attention, for a number of successive nights, we shall find that by far the greater part of the stars never vary their positions with respect to each other. If we observe two stars at a certain apparent distance from each other, either north or south, or in any other direction, they will appear at the same distance and in the same relative position to each other the next evening, the next month, and the next year. The stars, for instance, which form the *sword* and *belt* of *Orion* present to our eye the same figure and relative aspect during the whole period they are visible in winter, and from one year to another; and the same is the case with all the fixed stars in the firmament. On examining the sky a little more minutely, however, we perceive certain bodies which regularly shift their positions. Sometimes they appear to move towards the east, sometimes towards the west, and at other times seem to remain in a stationary position. These bodies have obtained the name of *planets*, or wandering stars; and in our latitude are most frequently seen, either in the eastern and western, or in the southern parts of the heavens. Thirty-three of these planetary orbs have been discovered: twenty-nine of which are, for the most part, invisible to the naked eye. By a careful examination of the motions of these bodies, and their different aspects, astronomers have determined that they all move round the sun as the centre of their motions, and form, along with the earth and several smaller globes, one grand and harmonious system. This assemblage of planetary

bodies is generally termed the Solar System, of which I shall now exhibit a brief outline.

The Solar System.

The Solar system, in brief, consists of a central sun, round which revolve at various distances and velocities, thirty-three planets,



TELESCOPIC APPEARANCE OF THE MOON.

which have been placed in four groups for the convenience of reference. To these have been added several others, which from their minuteness have been termed planetoids. In the old system of astronomy, the planets were said to be six only, which are known by the mythological names of Mercury, Venus, Tellus (the Earth), Mars, Jupiter, and Saturn. About three quarters of a

century since, a seventh planet was added to the list—Uranus or Herschel, discovered (in 1781) by Sir William Herschel, which revolves in an orbit beyond that of Saturn. To this list of seven principal planets, M. Le Verrier and Mr. Adams, the astronomers, have within the last few years given a seventh, which has been called Neptune. It is calculated that this planet is thirty times farther from the sun than the earth, and that the period of its revolution round the central orb occupies a period equal to 164 of our years.

Of the large group of planets, or planetoids, which revolve round the sun in orbits between those of Mars and Jupiter, we shall have to speak at greater length.

As I have already said, the sun is the centre and animating principle of our solar system. The first thing that strikes the mind when contemplating this glorious orb is its astonishing magnitude. This vast globe is found to be about 880,000 miles in diameter, and consequently contains a mass of matter equal to 1,300,000 globes of the size of the earth. Were its central parts placed adjacent to the surface of the earth, its circumference would reach 200,000 miles beyond the moon's orbit, on every side, filling a cubical space of 356,818,739,200,000,000 miles. If it would require 18,000 years to traverse every square mile on the earth's surface, at the rate of thirty miles a-day,[1] it would require more than 200,000,000 of years to pass over every part of the sun's surface, at the same rate. Even at the rate of ninety miles a-day, it would require more than eighty years to go round its circumference. Of a body so vast in its dimensions the human mind, with all its efforts, can form no adequate conception. It appears an extensive universe in itself; and although no other body existed within the range of infinite space, this globe alone would afford a powerful demonstration of the omnipotence of the Creator. Were the sun a hollow sphere, surrounded by an external shell and a luminous atmosphere; were this shell perforated with several hundreds of openings into the internal parts; were a globe as large as the earth placed at its centre, and another globe as large as the moon, and at the same distance from the centre as the moon is from us, to revolve round the central globe—it would present to the view a universe as splendid and glorious as that which now appears to the vulgar eye—a universe as large and extensive as

[1] See page 40.

the whole creation was conceived to be by our ancestors, in the infancy of astronomy. And who can tell but that Almighty Being, who has not left a drop of water in a stagnant pool without its inhabitants, has arranged a number of worlds within the capacious circuit of the sun, and peopled them with intelligent beings in the first stages of their existence, to remain there for a certain period, till they be prepared for being transported to a more expansive sphere of existence? It is easy to conceive that enjoyments as exquisite, and a range of thought as ample as have ever yet been experienced by the majority of the inhabitants of our world, might be afforded to myriads of beings thus placed at the centre of this magnificent luminary. This supposition is at least as probable as that of the celebrated Sir W. Herschel, who supposed that the *exterior* surface of the sun was peopled with inhabitants. For if this were the case, the range of view of these inhabitants would be confined within the limits of 200 or 300 miles, and no celestial body, but an immense blaze of light would be visible in their hemisphere. Such is the variety which appears among the works of God, and such is the diversity of situations in which sensitive beings are placed, that we dare not pronounce it impossible that both these suppositions may be realized.

Though the sun seems to perform a daily circuit around our globe, he may be said in this respect to be fixed and immovable. This motion is not *real*, but only *apparent*, and is owing to the globe on which we are placed moving round its axis from west to east; just as the objects on the bank of a river seem to move in a contrary direction when we are sailing along its stream in a steamboat. The only motion which is found to exist in the sun is a motion of *rotation*, like that of a globe or ball twirled round a pivot or axis, which is performed in the space of twenty-five days and ten hours. This motion has been ascertained by means of a variety of dark spots which are discovered by the telescope on the sun's disk; which first appear on his eastern limb, and after a period of about thirteen days disappear on his western, and after a similar period re-appear on his eastern edge. These spots are various, both in number, in magnitude, and in shape: sometimes forty or fifty, and sometimes only one or two are visible, and at other times the sun appears entirely without spots. Most of them have a very dark nucleus, or central part, surrounded by an umbra, or fainter shade. Some of the spots are as large as would cover the

whole continent of Europe, Asia, and Africa; others have been observed of the size of the whole surface of the earth; and one was seen, in the year 1779, which was computed to be more than 50,000 miles in diameter.

With regard to the nature of this globe, it appears highly probable, from the observations of Sir W. Herschel, that the sun is a solid and opaque body, surrounded with luminous clouds which float in the solar atmosphere, and that the dark nucleus of the spots is the opaque body of the sun appearing through occasional openings in this atmosphere. The height of the atmosphere he computes to be not less than 1843 nor more than 2765 miles, consisting of two regions; that nearest the sun being opaque, and probably resembling the clouds of our earth: the outermost emitting vast quantities of light, and forming the apparent luminous globe we behold.

The sun is the grand source of light and heat, both to the earth and to all the other planetary bodies. The heat he diffuses animates every part of our sublunary system, and all that variety of colouring which adorns the terrestrial landscape is produced by his rays. It has been discovered that the rays of light and the rays of heat, or *caloric*, are distinct from each other; for it can be demonstrated that some rays from the sun produce heat, which have no power of communicating light or colour. The greatest heat is found in the *red* rays, the least in the *violet* rays; and in a space beyond the red rays, where there is no light, the temperature is greatest. The rays of the sun have also been found to produce different chemical effects. The white muriate of silver is blackened in the violet ray in the space of fifteen seconds, though the red will not produce the same effect in less than twenty minutes. Phosphorous is kindled in the vicinity of the red ray, and extinguished in the vicinity of the violet. The solar light, therefore, consists of *three* different orders of rays, one producing *colour*, a second producing *heat*, and a third *chemical* effects. Euler has computed that the light of the sun is equal to 6500 candles at a foot distance, while the moon would be as one candle at seven and a-half feet; Venus at 421 feet; and Jupiter at 1320 feet.—That this immense luminary appears so small to our eyes is owing to its vast distance, which is no less than 95,000,000 of miles. Some faint idea of this distance may be obtained by considering that a steam-boat, moving at the rate of 200 miles a-day, would

require 1300 years before it could traverse the space which intervenes between us and the sun.

> "Hail, sacred source of inexhausted light!
> Prodigious instance of creating might.
> His distance man's imagination foils;
> Numbers will scarce avail to count the miles.
> As swift as thought he darts his radiance round
> To distant worlds, his system's utmost bound."

The planet MERCURY.—Mercury is the nearest planet to the sun that has yet been discovered. He is about thirty-seven millions of miles distant from the sun, and revolves around him in eighty-eight days. His diameter is about 3200 miles. Before the discovery of the four planets, Ceres, Pallas, Juno, and Vesta, in the beginning of the present century, this globe was considered as the smallest primary planet in the system. His surface, however, contains above thirty-two millions of square miles, which is not much less than all the habitable parts of our globe. On account of his nearness to the sun he is seldom seen by the naked eye; being always near that quarter of the heavens where the sun appears; and therefore few discoveries have been made on his surface by the telescope. M. Schroeter concludes, from certain observations, that this planet revolves round its axis in twenty-four hours and five minutes. The sun will appear to an inhabitant of Mercury seven times larger than to an inhabitant of the earth: and if the degree of heat be in proportion to a planet's nearness to the sun, the heat in this planet will be seven times greater than on the surface of our globe; and consequently, were the earth placed in the same position, all the water on its surface would boil, and soon be turned into vapour. But the all-wise Creator has doubtless attempered the surface of this globe, and the constitution of the beings that may occupy it, to the situation in which they are placed.[1]

[1] From a variety of facts which have been observed in relation to the production of *Caloric*, it does not appear probable that the degree of heat on the surfaces of the different planets is inversely proportional to the squares of their respective distances from the sun. It is more probable that it depends chiefly on the distribution of the *substance of caloric* on the surfaces and throughout the atmospheres of these bodies—in different quantities according to the different situations they occupy in the Solar system; and that these different quantities of caloric are put into action by the influence of the solar rays, so as to produce that degree of *sensible* heat re-

VENUS, the next planet in order, revolves around the sun in 224 days, at the distance of sixty-eight millions of miles: its diameter is about seven thousand seven hundred miles, or nearly the size of the earth; and it turns round its axis in the space of twenty-three hours and twenty minutes. This planet is the most brilliant orb which appears in the heavens, and is usually distinguished by the name of the morning and the evening star. When it approaches nearest to the earth, it is about twenty seven millions of miles distant; and, at its greatest distance, it is no less than 163 millions of miles from the earth. Were the whole of its enlightened surface turned towards the earth when it is nearest, it would exhibit a light and brilliancy twenty-five times greater than it generally does, and appear like a small brilliant moon; but at that time its dark hemisphere is turned towards our globe. Both Venus and Mercury, when viewed by a telescope, appear to pass successively through all the shapes and appearances of the moon; sometimes assuming a gibbous phase, and at other times the form of a half moon, or that of a crescent; which proves that they are dark bodies in themselves, and derive their light from the sun. The most distinct and beautiful views of Venus, especially when it appears as a crescent, are to be obtained in *the day time*, by means of an equatorial telescope.—From a variety of observations which the Author has made with this instrument, it has been found that Venus may be seen every clear day, without interruption, during a period of 583 days, with the occasional exception of eight days in one case and only three days in another—circumstances which cannot be affirmed of any other celestial body, the sun only excepted.[1] M. Schroeter affirms that he has discovered

quisite for each respective planetary globe. On this hypothesis—which is corroborated by a great variety of facts and experiments—there may be no more sensible heat felt on the surface of the planet Mercury than on the surface of Uranus, although one of these bodies is nearly fifty times nearer the sun than the other. We have only to suppose that a small quantity of caloric exists in Mercury and a larger quantity in Uranus, proportionate to his distance from the centre of the system. On this ground, we have no reason to believe either that the planets nearest the sun are parched with excessive heat, or that those that are most distant are exposed to all the rigours of unsufferable cold, or that the different degrees of temperature which may be found in these bodies render them unfit for being the abodes of sensitive and intellectual beings.

1 See Edin. Phil. Journ., No. V, July, 1820, and No. XIII, July, 1822.

FIG. 4. FIG. 5.

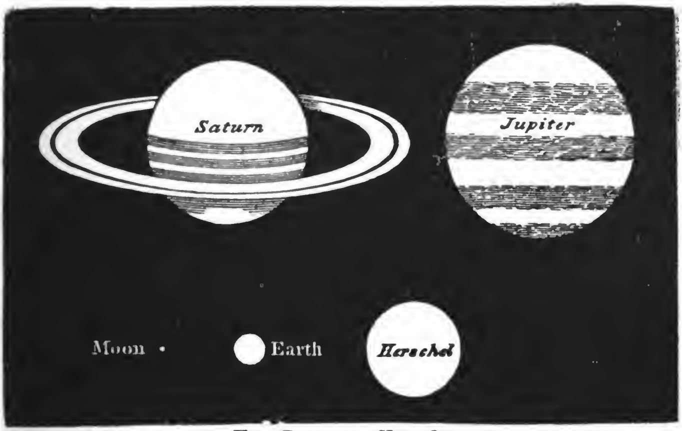
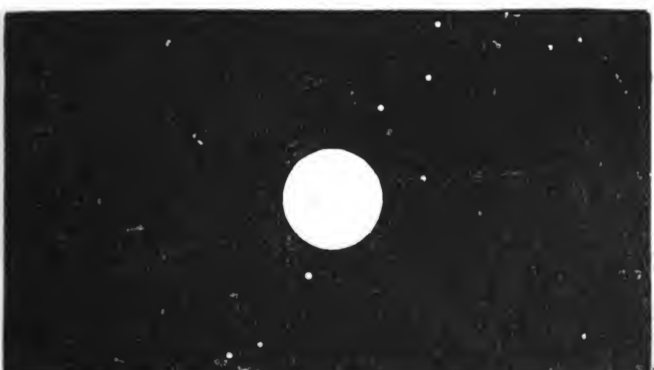


FIG. 6. FIG. 7. FIG. 8.

RELATIVE SIZES OF THE PLANETS.

FIG. 9.



HERSCHEL AND MOONS.

mountains on the surface of this globe, one of which is ten, another eleven, and a third twenty-two miles high. It appears also to be encompassed with an atmosphere, the densest part of which is about 16,000 feet high. About twice in the course of a century this planet appears to pass, like a dark spot, across the sun's disk. This is termed the *transit* of Venus. The last transit happened June 3, 1769; the next will happen on December 8, 1874, which will be invisible in Europe. Another will happen on the 6th December, 1882, which will be partly visible in Great Britain.

The EARTH is the next planet in the system. It moves round the sun in 365 days, five hours, and forty-nine minutes, at the distance of ninety-five millions of miles, and round its axis in twenty-three hours, fifty-six minutes, four seconds. The former is called its *annual*, and the latter its *diurnal* motion. That the earth is, in reality, a moving body, is a fact which can no longer be called in question; it is indeed susceptible of the clearest demonstration. But my limits will not permit to enter into a detail of the argu-

—I have found from observation that this planet may be seen in the day-time, when only fifty-eight minutes from the sun's centre; and consequently, when its geocentric latitude at the time of the superior conjunction exceeds that quantity, it may be distinctly seen during the whole period of 583 days excepting about thirty-five hours before and after its *inferior* conjunction.—It is well known to astronomers that there has been a difference of opinion with respect to the *period* of the rotation of this planet. Cassini, from observations on a bright spot which advanced twenty degrees in twenty-four hours, thirty-four minutes, determined the time of its rotation to be twenty-three hours, and twenty minutes. On the other hand, Bianchini, from similar observations, concluded that its diurnal period was twenty-four days, and eight hours. The difficulty of deciding between these two opinions arises from the short time in which observations can be made on this planet, either before sun-rise or after sun-set, which prevents us from tracing with accuracy the progressive motion of its spots for a sufficient length of time. And although an observer should mark the position of the spots, at the same hour, on two succeeding evenings, and find they had moved forward about twenty degrees in twenty-four hours, he would still be at a loss to determine whether they had moved twenty degrees *in all*, since the preceding observation, or had finished a revolution, and twenty degrees more.—In Nicholson's Philosophical Journal, vol. xxxvi, I endeavour to show how this point may be determined by observations made on Venus in the day-time, by which, in certain cases, the progressive motion of its spots might be traced, without interruption, for twelve hours or more, which would completely settle the period of rotation.

ments by which it is supported. I have already adverted to one consideration, from which its diurnal rotation may be inferred.[1] Either the earth moves round its axis every day, or *the whole universe* moves round it in the same time. To suppose the latter case to be the fact would involve a reflection on the wisdom of its Almighty Author, and would form the only exception that we know to that beautiful proportion, harmony, and simplicity, which appear in all the works of Nature. Were it possible to construct a machine as large as the City of London, and to apply to it mechanical powers sufficient to make it revolve on an axis, so as to carry round a furnace for the purpose of roasting a joint of mutton, suspended in the centre of its motion—while we might admire the ingenuity and the energies displayed in its construction—all mankind would unite in condemning it as a display of consummate folly. But such an extravagant piece of machinery would not be half so preposterous as to suppose, that the vast universe is daily revolving round our little globe, and that all the planetary motions have an immediate respect to it. And shall we dare to ascribe to Him who is "the only wise God" contrivances which we would pronounce to be the perfection of folly in mankind? It is recorded of the astronomer Alphonsus, king of Castile, who lived in the thirteenth century, that, after having studied the Ptolemaic system, which supposes the earth at rest in the centre of the universe, he uttered the following *impious* sentence: "If I had been of God's privy council when he made the world, I would have advised him better." So that false conceptions of the system of nature lead to erroneous notions of that adorable Being who is possessed of infinite perfection.—We find that bodies much larger than the earth have a similar rotation. The planet Jupiter, a globe 295,000 miles in circumference, moves round its axis in less than ten hours; and all the other planetary bodies, on which spots have been discovered, are found to have a diurnal motion. Besides, it is found to be a universal law of nature, that smaller globes revolve around larger, but there is no example in the universe, of a larger body revolving around a smaller. The moon revolves around the earth, but she is much smaller than the earth; the moons which move around Jupiter, Saturn, and Herschel, are all less than their primaries, and the planets which perform their revolutions around the sun are much less than that central luminary. A means of mechanically

[1] See pp. 53, 54.

demonstrating the earth's motion was supposed to have been discovered two or three years since, but the idea is now exploded.[1]

With regard to the *annual* revolution of the earth,—if such a motion did not exist, the planetary system would present a scene of inextricable confusion. The planets would sometimes move

[1] An ingenious expedient by which the diurnal motion of the earth is rendered visible has been conceived and reduced to experiment by M. Leon Foucault, who explains his theory in the following manner:—This contrivance is based upon the principle that the direction of the plane of vibration of a pendulum is not affected by any motion of translation which may be given to its point of suspension. Thus, if a pendulum suspended in a room, and put into vibration in a plane parallel to one of the walls, be carried round a circular table, the plane of its vibration will continually be parallel to the same wall, and will therefore vary constantly in the angle it forms with the radius of the table which is directed to it. Now, if a pendulum suspended any where so near the pole of the earth, that the circle round the pole may be considered a plane, be put in vibration in a plane passing through the pole, this plane continuing parallel to its original direction, as it is carried round the pole by the earth's rotation, will make a varying angle with a line drawn to the pole from the position it occupies. After being carried through a quarter of a revolution, it will make an angle of ninety degrees with the line to the pole, and so on. In fine, the direction of the pole will appear to be carried round the plane of vibration of the pendulum. The same effects will be produced at greater distances from the pole, but the rate of variation of the angle under the plane of vibration, and the plane of the meridian will be different, owing to the effects of the curvature of the meridian.

This phenomenon, therefore, being a direct effect of the rotation of the earth, supplies a proof of the existence of that motion attainable without reference to objects beyond the limits of the globe.

This experiment may be tried thus:—Suspend from the ceiling of a room a pendulum, consisting of a globe supported by a fine wire, so that it may vibrate freely in any plane; immediately under the pendulum, when at rest, describe on the floor or on a table, a circle divided into degrees, then imparting motion to the pendulum in any plane, say, for instance, in a plane agreeing with the meridian, it will be found, if narrowly watched, that the pendulum, although oscillating in an invariable plane, according to the known laws of motion, will not return to the exact point of the circle from which it started, but it will apparently traverse gradually in its vibrations round the circle in a direction contrary to the apparent motion of the heavens. The plane of the vibration of the pendulum being unchanging, it follows that the table or the floor must be revolving, and this can only be accounted for on the supposition that the earth is continually revolving on its axis.

backwards, sometimes forwards, and at other times remain stationary; and would describe looped curves, so anomalous and confused that no man in his senses could view the all-wise Creator as the author of so much confusion. But, by considering the earth as revolving in an orbit between Venus and Mars, (which all celestial observations completely demonstrate,) all the apparent irregularities of the planetary motions are completely solved and accounted for; and the Solar system presents a scene of beauty, harmony, and grandeur, combined with a simplicity of design, which characterizes all the works of Omnipotence.

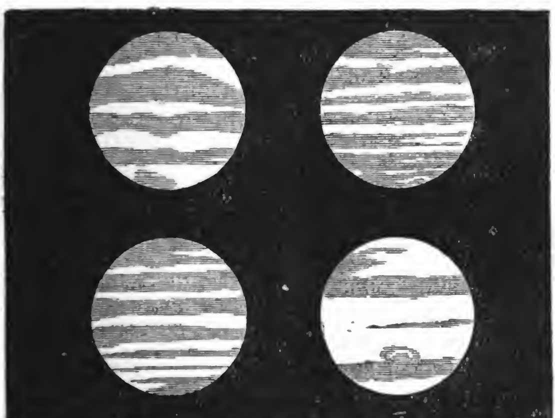
The Moon.—Next to the sun, the moon is to us the most interesting of all the celestial orbs. She is the constant attendant of

A PORTION OF THE MOON'S SURFACE.

Fig. 10.

JUPITER AND HIS SATELLITES.

Fig. 11.



JUPITER AND HIS BELTS.

the earth, and revolves around it in twenty-seven days, eight hours; but the period from one new or full moon to another is about twenty-nine days, twelve hours. She is the nearest of all the heavenly bodies; being only about two hundred and forty thousand miles distant from the earth. She is much smaller than the earth; being only 2180 miles in diameter. Her surface, when viewed with a telescope, presents an interesting and variegated aspect; being diversified with mountains, valleys, rocks, and plains, in every variety of form and position. Some of these mountains form long and elevated ridges, resembling the chains of the Alps and the Andes; while others of a conical form, rise to a great height, from the middle of level plains, somewhat resembling the peak of Teneriffe. But the most singular feature of the moon is those circular ridges and cavities which diversify every portion of her surface. A range of mountains of a circular form, rising three or four miles above the level of the adjacent districts, surrounds, like a mighty rampart, an extensive plain, and in the middle of this plain or cavity, an insulated conical hill rises to a considerable elevation. Several hundreds of these circular plains, most of which are considerably below the level of the surrounding country, may be perceived with a good telescope, on every region of the lunar surface. They are of all dimensions, from two or three miles to forty miles in diameter; and, if they be adorned with verdure, they must present to the view of a spectator, placed among them, a more variegated, romantic, and sublime scenery than is to be found on the surface of our globe. An idea of some of these scenes may be acquired by conceiving a plain of about 100 miles in circumference, encircled with a range of mountains, of various forms, three miles in perpendicular height, and having a mountain near the centre, whose top reaches a mile and a half above the level of the plain. From the top of this central mountain, the whole plain, with all its variety of objects, would be distinctly visible; and the view would appear to be bounded on all sides by a lofty amphitheatre of mountains, in every diversity of shape, rearing their summits to the sky. From the summit of the circular ridge, the conical hill in the centre, the opposite circular range, the plain below, and some of the adjacent plains, which encompass the *exterior* ridge of the mountains, would form another variety of view;—and a third variety would be obtained from the

various aspects of the central mountain, and the surrounding scenery as viewed from the plains below.

The lunar mountains are of all sizes, from a furlong to five miles in perpendicular elevation. Certain luminous spots, which have been occasionally seen on the dark side of the moon, seem to demonstrate that fire exists in this planet. Sir W. Herschel, and several other astronomers, suppose that they are volcanoes in a state of eruption. It would be a more pleasing idea, and perhaps as nearly corresponding to fact, to suppose, that these phenomena are owing to some occasional splendid illuminations produced by the lunar inhabitants during their long nights. Such a scene as the burning of Moscow, or Sebastopol, the conflagration of an extensive forest, or the splendid illumination of a large city with gas-light, might present similar appearances to a spectator in the moon—the bright spots on the moon are the mountainous regions; the dark spots are the plains, or more level parts of the surface. There may probably be rivers or small lakes on this planet; but there appear to be no seas or large collections of water. It appears highly probable, from the observations of Schroeter, that the moon is encompassed with an atmosphere: but no clouds, rain, or snow seem to exist in it. The illuminating power of the light derived from the moon, according to the experiments made by professor Leslie, is about the 150,000th part of the illuminating power of the sun. According to the experiments of M. Bouguer, it is only as one to 300,000.

The moon always presents the same face to us, which proves, that she revolves round her axis in the same time that she revolves round the earth. As this orb derives its light from the sun, and reflects a portion of it upon the earth, so the earth performs the same office to the moon. A spectator on the lunar surface would behold the earth like a luminous orb suspended in the vault of heaven, presenting a surface about thirteen times larger than the moon does to us, and appears sometimes gibbous, sometimes horned, and at other times with a round full face. The light which the earth reflects upon the dark side of the moon may be distinctly perceived by a common telescope, from two to six or eight days after the change.—The lunar surface contains about fifteen millions of square miles, and is therefore capable of containing a population equal to that of our globe, allowing only about fifty-three inhabitants to

every square mile. That this planet is inhabited by sensitive and intelligent beings there is every reason to conclude, from a consideration of the sublime scenery with which its surface is adorned, and of the general beneficence of the Creator, who appears to have left no large portion of his material creation without animated existences; and it is highly probable, that *direct proofs* of the moon's being inhabited may hereafter be obtained, when all the varieties on her surface shall have been more minutely explored.[1]

The planet MARS.—Next to the earth and moon, the planet Mars performs his revolutions round the sun, in one year and ten months, at the distance of 145 millions of miles. His diameter is about 4200 miles, and he is distinguished from all the other planets by his *ruddy* appearance, which is owing to a *dense atmosphere* with which he is environed. With a good telescope, his surface appears diversified with a variety of spots; by the motion of which it is found, that he turns round his axis in twenty-four hours, and forty minutes. The inclination of his axis to the plane of his orbit being about twenty-eight degrees forty-two minutes, the days and nights, and the different seasons in this planet, will bear a considerable resemblance to those we experience in our terrestrial sphere.[2] At his nearest approach to the earth, his distance from us is about fifty millions of miles; and, at his greatest distance, he is about 240 millions of miles; so that in the former case he appears nearly twenty-five times larger than in the latter. To a spectator in this planet our earth will appear alternately as a morning and evening star, and will exhibit all the phases of the moon, just as Venus does to us, but with a less degree of apparent magnitude and splendour. A luminous zone has been observed about the poles of Mars, which is subject to successive changes. Sir W. Herschel supposes that it is produced by the reflection of the sun's light from his frozen regions, and that the melting of these masses of polar ice is the cause of the

[1] See Appendix, Note IV.

[2] The inclination of the earth's axis to the ecliptic, or in other words, to the plane of its annual orbit, is twenty-three degrees, twenty-eight minutes, which is the cause of the diversity of seasons, and of the different length of days and nights. Were the axis of the earth perpendicular to its orbit, as is the case with the planet Jupiter, there would be no diversity of seasons.

variation in its magnitude and appearance. This planet moves, in its orbit, at the rate of 55,000 miles an hour.

The New Planets.—Between the orbits of Mars and Jupiter, four planetary bodies were discovered in the beginning of the present century, accompanied with circumstances somewhat different from those of the other bodies which compose our system. They are named *Ceres*, *Pallas*, *Juno*, and *Vesta*. The planet *Ceres* was discovered at Palermo in Sicilly, by M. Piazzi, on the first day of the year 1801. It is of a ruddy colour, and appears about the size of a star of the eighth magnitude, and is consequently invisible to the naked eye. It performs its revolutions in four years and seven months, at the distance of 260 millions of miles from the sun, and is reckoned by some astronomers to be about 1624 miles in diameter, or about half the diameter of mercury. It appears to be surrounded with a large dense atmosphere.—Pallas was discovered the following year, namely, on the 28th March, 1802, by Dr. Olbers of Bremen. It is supposed to be about 2000 miles in diameter, or nearly the size of the moon. It revolves about the sun in four years and seven months, or nearly in the same time as Ceres, at the distance of 266 millions of miles; and is surrounded with a nebulosity or atmosphere above 400 miles in height, similar to that of Ceres.—The planet *Juno* was discovered on the 1st September, 1804, by Mr. Harding of Bremen. Its mean distance from the sun is about 253 millions of miles; its revolution is completed in four years and 130 days, and its diameter is computed to be about 1425 miles. It is free from the nebulosity which surrounds Pallas, and is distinguished from all the other planets by the great eccentricity of its orbit; being at its least distance from the sun only 189 millions of miles, and at its greatest distance, 316 millions.—*Vesta* was discovered by Dr. Olbers on the 29th March, 1807. It appears like a star of the fifth or sixth magnitude, and may sometimes be distinguished by the naked eye. Its light is more intense and white than any of the other three, and it is not surrounded with any nebulosity. It is distant from the sun about 225 millions of miles, and completes its revolutions in three years and 240 days. Its diameter has not yet been accurately ascertained; but from the intensity of its light and other circumstances, it is concluded, that it is not inferior in magnitude to either Pallas or Juno.

Another planet, which bears a striking resemblance to those we have now described, was discovered by M. Hencke of Driessen, in Prussia, on the 8th of December, 1845. It appeared like a star of the ninth magnitude, in a place where before there was none. Its place on the 14th of December, as found by Professor Encke of Berlin at six hours, twenty-eight minutes, was right ascension sixty-four degrees, four minutes, fifty-three seconds. At thirteen hours, thirty-four minutes, fifty-five seconds, its right ascension, in time, was four hours, sixteen minutes. North declination, twelve degrees, thirty-nine minutes, fifty-two seconds. Its motion was retrograde, and its daily amount, as determined from the observations, eight hours apart, was in right ascension, fourteen minutes, twenty-one seconds. In declination its motion was quite insignificant. This moving body was afterward observed in England by Messrs. South, Airy, and others, and from their observations, and those of foreign astronomers, it has now been determined to be a planet belonging to the Solar system, and that it revolves between the orbits of Mars and Jupiter. Astronomers have given it the name of *Astræa.* From the notes of the positions of this planet as given by Encke and Schumacher, M. Faye, a French astronomer, has calculated the elements of its orbit; they are as follows:—

	Degrees.	Minutes.
Epoch, 1845, Dec. 14,	71	13·6
Longitude of Ascending Node,	135	14·6
Inclination of orbit,	6	1·2
Semidiameter of orbit.	26·024	
Movement,	Direct.	
Period of Sidereal revolution,	4 years.	2 months.

From all the circumstances now stated, it appears that the new planet Astræa has a certain relation to the four small planets above described. This relation will appear still more striking, if we compare their elements, as in the following statement:—

	Mean dis. from the Sun.	Mean period in days.	Inclination of orbit.
Vesta,	2·3678	1325	7° 8′ 9″
Juno,	2·6690	1592	13 4 9
Ceres,	2·7672	1681	10 37 26
Pallas,	2·7728	1686	34 34 55
Astræa,	2·6024	1521	6 1 2

In the *distances* of these planets here stated, the distance of the earth from the sun is taken as a unit. Thus, if the distance of the earth from the sun be 95,000,000 of units, the distance of Vesta, here stated 2·3678 multiplied by 95 produces 224·9410, or nearly 225,000,000 of miles. The distance of Astræa from the sun, is, therefore, to that of the earth as 2·6024 to 1·0000, or in round numbers, as 26 to 10, or in miles, by multiplying 2·6024 by 95; 247,000,000 of miles. In the inclination of its orbit, it agrees most nearly with Vesta; but in its distance and period of revolution, it bears the nearest resemblance to Juno.

A multitude of smaller planets have been since discovered by various professional and amateur astronomers. The discovery of the planet Astræa appears to give an immense impetus to astronomical science. Within the last few years many private observatories have been established, and the result has been the discovery of no fewer than thirty-six new planets or planetoids, all occupying about the same place in the system—that is, between the orbits of Mars and Jupiter, in which position it had long been supposed that a planet had originally existed. The order of these discoveries is as follows:—in 1847, three were discovered; in 1848, one; in 1849, one; in 1850, three; in 1851, two; in 1852, eight; in 1853, four; in 1854, six; and in the present year, 1855, two; one of which has not yet been named. The total number of planetoids, therefore, including Ceres, Pallas, Juno, Vesta, and Astræa, is thirty-five. In the accompanying table, the particulars of these discoveries may be seen at a glance. Of these thirty-six new planets, no fewer than twelve have been discovered by Mr. Hind, at the private observatory of Mr. Bishop, in the Regent's Park; five by M. De Gasparis, assistant astronomer at the Royal Observatory at Naples; and two by Mr. Hermann Goldschmidt, an historical teacher, of Paris, with an ordinary telescope, placed on the balcony of his house. The extreme minuteness of these planetoids is such that it would take 512,000 to make a sphere as large our earth. How great is the power of the Author of the world!

CATALOGUE OF THE MINOR PLANETS IN THE ORDER OF THEIR DISCOVERY.

NAME OF PLANETS.	Date of Discovery.	Name of Discoverer.	Magnitude.	Mean daily Sidereal motion.	Mean distance from the Sun, (Earth as unity.)	Sidereal Revolution in Days.
				M. S.		
Ceres, . .	January, 1801,	Piazzi,	8	12 51	2·77	1680
Pallas, . .	March, 1802,	Olbers,	7	12 49	2·77	1686
Juno, . .	September, 1804,	Harding,	8	13 34	2·67	1592
Vesta, . .	March, 1807,	Olbers,	7	16 17	2·36	1326
Astræa, . .	December, 1845,	Hencke,	9	14 18	2·58	1511
Hebe, . .	July, 1847,	Hencke,	9	15 39	2·43	1388
Iris, . .	August, 1847,	Hind,	9	16 3	2·39	1346
Flora, . .	October, 1847,	Hind,	9	18 6	2·20	1193
Metis, . .	April, 1848,	Graham,	10	16 2	2·39	1347
Hygeia, . .	April, 1849,	Gasparis,	9	10 35	3·15	2041
Parthenope, .	May, 1850,	Gasparis,	9	15 24	2·45	1402
Victoria, . .	September, 1850,	Hind,	8	16 35	2·33	1300
Egeria, . .	November, 1850,	Gasparis,	9	14 17	2·58	1512
Irene, . .	May, 1851, / May, 1851,	Hind, / Gasparis,	9	14 14	2·59	1518
Eunomia, . .	July, 1851,	Gasparis,	9	13 46	2·64	1570
Psyche, . .	March, 1852,	Gasparis,	10	11 50	2·92	1825
Thetis, . .	April, 1852,	Luther,	10	15 12	2·47	1421
Melpomene, .	June, 1852,	Hind,	9	17 0	2·30	1271
Fortuna, . .	August, 1852,	Hind,	9	15 29	2·44	1395
Massilia, . .	September, 1852,	Gasparis, / Chacomac,	9	15 50	2·41	1364
Lutetia, . .	November, 1852,	Goldschmidt,	9	15 34	2·44	1388
Calliope, . .	November, 1852,	Hind,	9	11 53	2·91	1817
Thalia, . .	December, 1852,	Hind,	10	13 54	2·63	1514
Themis, . .	April, 1853,	Gasparis,	12	10 36	3·14	2037
Phocea, . .	April, 1853,	Chacomac,	9	15 54	2·40	1359
Proserpine, .	May, 1853,	Luther,	11	13 40	2·66	1581
Uterpe, . .	November, 1853,	Hind,	9	16 27	2·35	1311
Bellona, . .	March, 1854,	Luther,	10	12 48	2·78	1689
Amphitrite, .	March, 1854, / March, 1854, / March, 1854,	Marth, / Pogson, / Chacomac,	10	14 29	2·55	1491
Urania, . .	July, 1854,	Hind,	9	16 0	2·39	1350
Euphrosyne, .	September, 1854,	Ferguson,	10	10 33	3·16	2048
Pomona, . .	October, 1854,	Goldschmidt,	11	14 17	2·58	1512
Polyhymnia, .	October, 1854,	Chacomac,	10	12 5	2·88	1787
(Not named), .	April, 1855,	Chacomac,	11	13 41	2·65	1574
Leucothea, .	April, 1855,	Luther,				
(Not named). .	September, 1855,	Hind,				

The fourth column shows the estimated magnitude or degree of brightness.
The fifth column shows the daily sidereal motion, or the space through which each planet would move in a day, and describes a circle round the sun of its average velocity.
The sixth column shows the mean distance of each planetoid from the sun.
The seventh column shows the length of the sidereal revolution of each planet in days that is to say, the length of each planet's year.

The discovery of these planets may be considered as affording a corroboration of the hypothesis which supposes the four small planets formerly discovered to have originated from the disruption of a large planet, which formerly revolved in an orbit not far removed from those of these planets. If such a catastrophe actually happened, its cause, either physical or moral, is involved in a great mystery; but such an event would not be inconsistent with what we already know of the dispensations of the Almighty. For we know, in respect to the globe on which we live, that, at a certain period, its strata were disrupted, "the fountains of the great deep broken up, the cataracts of heaven opened," and a flood of waters ensued, which transformed the earth into one boundless ocean.—Without supposing such a catastrophe, as we have alluded to, to have taken place, we cannot account for the peculiarities of these planets which we are now about to state.

These planetary globes present to our view a variety of anomalies and singularities, which appear incompatible with the regularity, proportion, and harmony, which were formerly supposed to characterise the arrangements of the Solar system.—They are bodies *much smaller* in size than the other planets—they revolve *nearly at the same distances* from the sun, and perform their revolutions in *nearly the same periods*—their orbits are *much more eccentric*, and have a *much greater degree of inclination* to the ecliptic than those of the old planets; and, what is altogether singular (except in the case of comets), *their orbits cross each other;* so that there is a *possibility* that two of these bodies might happen to interfere, and to strike each other, in the course of their revolutions. The orbit of Ceres crosses the orbit of Pallas. Vesta may sometimes be at a greater distance from the sun than either Ceres, Pallas, or Juno, although its mean distance is less than that of either of them, by several millions of miles; so that the orbit of Vesta crosses the orbits of all the other three. From these and other circumstances, it has, with a high degree of probability, been concluded—that all these planets are the fragments of a large celestial body which once revolved between Mars and Jupiter, and which had been burst asunder by some immense irruptive force. This idea seems to have occurred to Dr. Olbers, after he had discovered the planet Pallas, and he imagined that other fragments might possibly exist. He concluded, that, if they all diverged from the same point, "they ought to have two common points of re-union, or two nodes

in opposite regions of the heavens, through which all the planetary fragments must sooner or later pass." One of these nodes he found to be in the constellation Virgo, and the other in the Whale; and it is a remarkable coincidence, that it was in the latter of these regions that the planet Juno was discovered by Mr. Harding. In order to detect the remaining fragments, (if any existed), Dr. Olbers examined, three times every year, all the small stars in Virgo and the Whale; and it was actually in the constellation Virgo that he discovered the planet Vesta. It is not unlikely that other fragments of a similar description may yet be discovered. Sir D. Brewster attributes the fall of meteoric stones[1] to the smaller fragments of these bodies happening to come within the sphere of the earth's attraction. His ingenious reasoning on this subject, and in support of Dr. Olbers' hypothesis above stated, may be seen in *Edin. Encyc.*, vol. ii, p. 641, and in his "supplementary chapters to Ferguson's Astronomy."

The facts to which I have now adverted seem to unfold a new scene in the history of the dispensations of the Almighty, and to warrant the conclusion, that the earth is not the only globe in the universe which is subject to physical changes and moral revolutions.

The planet Jupiter.—This planet is 490 millions of miles distant from the sun, and performs its annual revolution in nearly twelve of our years, moving at the rate of 29,000 miles an hour. It is the largest planet in the Solar system; being 89,000 miles in diameter, or about *fourteen hundred times* larger than the earth. Its motion round its axis is performed in nine hours and twenty-six minutes; and, therefore, the portions of its surface about the equator move at the rate of 28,000 miles an hour, which is nearly

[1] Meteoric stones, or what are generally termed *aerolites*, are stones which sometimes fall from the upper regions of the atmosphere upon the earth. The substance of which they are composed is, for the most part, *metallic;* but the ore of which they consist is not to be found *in the same constituent proportions* in any terrestrial substances. Their fall is generally preceded by a luminous appearance, a hissing noise, and a loud explosion; and, when found immediately after their descent, are always hot. Their size differs from small fragments of inconsiderable weight, to the most ponderous masses. Some of the larger portions of these stones have been found to weigh from 300 lbs to several tons; and they have often descended to the earth with a force sufficient to bury them several feet under the soil. Some have supposed that these bodies are projected from volcanoes in the moon; others that they proceed from volcanoes on the earth; while others imagine that they are generated in the regions of the atmosphere; but the true cause is probably not yet ascertained. In some instances, these stones have penetrated through the roofs of houses, and proved destructive to the inhabitants.

twenty-seven times swifter than the earth's diurnal rotation. The figure of Jupiter is that of an oblate spheroid, the axis, or diameter, passing through the poles, being about 6000 miles shorter than that passing through the equator. The Earth, Saturn, and Mars, are also spheroids; and it is highly probable that Mercury, Venus, and Herschel, are of a similar figure, though the fact has not yet been ascertained by actual observation. When viewed with a telescope, several spots have been occasionally discovered on the surface of this planet, by the motion of which its rotation was determined.

But what chiefly distinguishes the surface of Jupiter is several streaky appearances, or dusky stripes which extend across his disk in lines parallel to his equator. These are generally termed his *Belts*. Three of these belts, or zones, nearly equi-distant from each other, are most frequently observed; but they are not regular or constant in their appearance.[1] Sometimes only one is to be seen, sometimes five, and sometimes seven or eight have been visible; and in the latter case, two of them have been known to disappear during the time of observation. On the 28th of May, 1780, Sir W. Herschel perceived "the *whole surface of Jupiter* covered with small curved belts, or rather lines, that were not continuous across his disk." Though these belts are generally parallel to each other, yet they are not always so. Their breadth is likewise variable; one belt having been observed to grow narrower, while another in its neighbourhood has increased in breadth, as if the one had flowed into the other. The time of their continuance is also uncertain; sometimes they remain unchanged for several months, at other times, new belts have been formed in an hour or two. What these belts, or variable appearances, are, it is difficult to determine. Some have regarded them as strata of clouds floating in the atmosphere of Jupiter; while others imagine, that they are the marks of great physical revolutions which are perpetually changing the surface of that planet. The former opinion appears the most probable. But whatever be the nature of these belts, the sudden changes to which they are occasionally subject seem to indicate the rapid operation of some powerful physical agency; for some of them are more than 5000 miles in breadth; and since they

[1] A representation of these belts in the positions in which they most frequently appear, is exhibited at p. 303, Fig. 5, Fig. 4, represents the double ring of Saturn as it appears when viewed through a powerful telescope. Figures 4, 5. 6. 7, and 8, represent Saturn, Jupiter, Herschel, the Earth, and Moon, *in their relative sizes and proportions.*

have been known to disappear in the space of an hour or two, and even during the time of a casual observation—agents more powerful than any with which we are acquainted must have produced so extensive an effect.

Jupiter is attended by four satellites, or moons, which present a very beautiful appearance when viewed through a telescope. The first moon, or that nearest the planet, is 230,000 miles distant from its centre, and goes round it in forty-two and a half hours; and will appear from its surface four times larger than our moon does to us. The second moon, being farther distant, will appear about the size of ours; the third, somewhat less; and the fourth, which is a million of miles distant from Jupiter, and takes sixteen days to go round him, will appear only about one-third the diameter of our moon. These moons suffer frequent eclipses from passing through Jupiter's shadow, in the same way as our moon is eclipsed by passing through the shadow of the earth. By the eclipses of these moons, the motion of light was ascertained; and they are found to be of essential use, in determining the longitude of places on the surface of our globe. This planet, if seen from its nearest moon, will present a surface one thousand times as large as our moon does to us, and will appear in the form of a crescent, a half moon, a gibbous phase, and a full moon, in regular succession, every forty-two hours.

Figure 10, page 309, exhibits a view of Jupiter's belts and satellites as seen through a good telescope; but they do not always appear, two on each side, as here represented, but in every variety of position; and sometimes all on the same side, in the order of their distances; and they seem to move from one side to another, in nearly straight lines, on account of our eye being nearly on a level with the planes of their orbits.

Jupiter's axis being nearly perpendicular to his orbit, he has no sensible change of seasons, such as we experience on the earth. Were we placed on the surface of this planet with the limited powers of vision we now possess, our earth and moon would entirely disappear, as if they were blotted out from the map of creation; and the inhabitants of these regions must have much better eyes than ours, if they know that there is in the universe such a globe as the earth.

The planet SATURN.—This planet is nine hundred millions of miles distant from the sun, being nearly double the distance of

Jupiter. Its diameter is 79,000 miles, and, consequently, it is more than nine hundred times the bulk of the earth. It takes twenty-nine and a half years to complete its revolution about the sun; but its diurnal motion is completed in ten hours and sixteen minutes; so that the year in this planet is nearly thirty times the length of ours, while the day is shorter, by more than one-half. The year, therefore, contains about 25,150 days, or periods of its diurnal rotation, which is equal to 10,759 of our days. Saturn is of a spheroidal figure, or somewhat of the shape of an orange; his equatorial being more than six thousand miles longer than his polar diameter. His surface, like that of Jupiter, is diversified with belts and dark spots. Sir W. Herschel, at certain times, perceived five belts on his surface, three of which were dark, and two bright. The dark belts had a yellowish tinge, and generally covered a larger zone of the disk of Saturn than the belts of Jupiter occupy upon his surface. On account of the great distance of this planet from the sun, the light it receives from that luminary is only the ninetieth part of what we enjoy: but, by calculation, it is found, that this quantity is one thousand times greater than the light which the full moon affords to us. Besides, it is surrounded by no fewer than seven moons, which supply it with light in the absence of the sun. Five of these moons were discovered during the seventeenth century, by Huygens and Cassini; and the sixth and seventh were discovered by Sir W. Herschel, in 1789, soon after his large forty feet reflecting telescope was constructed. These moons, and also those which accompany Jupiter, are estimated to be not much less than the earth in magnitude, and are found, like our moon, to revolve round their axis in the same time in which they revolve about their respective primaries.

Rings of Saturn.—The most extraordinary circumstance connected with this planet is the phenomenon of a *double ring*, which surrounds its body, but nowhere touches it, being 30,000 miles distant from any part of the planet, and is carried along with the planet in its circuit around the sun. This is the most singular and astonishing object in the whole range of the planetary system; no other planet being found environed with so wonderful an appendage: and the planets which may belong to other systems, being placed beyond the reach of our observations, no idea can be formed of the peculiar apparatus with which any of them may be furnished. This double ring consists of two concentric rings,

detached from each other; the innermost of which is nearly three times as broad as the outermost. The outside diameter of the *exterior* ring is 204,000 miles; and consequently, in circumference, will measure 640,000 miles, or eighty times the diameter of our globe. Its breadth is 7200 miles, or nearly the diameter of the earth. Were 450 globes, of the size of the earth, placed close to one another, on a plane, this immense ring would enclose the whole of them, together with all the interstices, or open spaces, between the different globes. The outside diameter of the *innermost* ring is 184,000 miles, and its breadth 20,000 miles, or about two-and-a-half times broader than the diameter of the earth. The dark space, or interval between the two rings, is 2800 miles. The breadth of both the rings, including the dark space between them, is 30,000 miles, which is equal to the distance of the innermost ring from the body of Saturn.

Figure 13 represents a view of Saturn and his rings as they would appear were our eye perpendicular to one of the planes of those rings; but our eye is never so much elevated above either plane as to have the visual ray standing at right angles to it; it is never elevated more than thirty degrees above the planes of the rings. When we view Saturn through a telescope, we always see the ring at an oblique angle, so that it appears of an *oval* form, the outward circular ring being projected into an ellipsis more or less oblong, according to the different degrees of obliquity with which it is viewed, as will be seen in figure 12, page 327.

These rings cast a deep shadow upon the planet, which proves that they are not shining *fluids*, but composed of solid matter. They appear to be possessed of a higher reflective power than the surface of Saturn; as the light reflected by them is more brilliant than that of the planet. One obvious use of this double ring is, to reflect light upon the planet in the absence of the sun: in all probability, it also serves as an ample habitation for myriads of sensitive and intelligent beings; for the surfaces of the two rings contain no less than 29,078 millions of square miles, or about six hundred times more than all the habitable parts of our globe, and it is not likely that, in the wise arrangements of the Creator, such an immense space would be left destitute of inhabitants: what other purposes it may be intended to subserve, in the system of Saturn, is at present to us unknown. The sun illuminates one side of it during fifteen years, or one-half of the period of the

planet's revolution; and, during the next fifteen years, the other side is enlightened in its turn. Twice in the course of thirty years, there is a short period, during which neither side is enlightened, and when, of course, it ceases to be visible; namely, at the time when the sun ceases to shine on one side, and is about to shine on the other. It revolves round its axis, and consequently around Saturn, in ten hours and a half, which is at the rate of 1000 miles in a minute, fifty-eighty times swifter than the earth's equator. When viewed from the middle zone of the planet, in the absence of the sun, the rings will appear like vast luminous arches, extending along the canopy of heaven, from the eastern to the western horizon; having an apparent breadth equal to a hundred times the apparent diameter of our moon, and will be seen darkened about the middle, by the shadow of Saturn.[1]

There is no other planet in the Solar system whose firmament will present such a variety of splendid and magnificent objects as that of Saturn. The various aspects of his seven moons, one rising above the horizon, while another is setting, and a third approaching to the meridian; one entering into an eclipse, and another emerging from it; one appearing as a crescent, and another with a gibbous phase; and sometimes the whole of them shining in the same hemisphere, in one bright assemblage; the majestic motions of the rings,—at one time illuminating the sky with their splendour, and eclipsing the stars; at another, casting a deep shade over certain regions of the planet, and unveiling to view the wonders of the starry firmament—are scenes worthy of the majesty of the Divine Being to unfold, and of rational creatures

[1] See page 327, Fig. 13, which represents a view of the appearance which the rings and moons of Saturn will exhibit, in certain cases, about midnight, when beheld from a point twenty or thirty degrees north from his equator. The shade on the upper part of the rings represents the shadow of the body of Saturn. This shadow will appear to move gradually to the west as the morning approaches. From observations which were made some time ago, by Captain Kater, Professor Quetelet, and others, it has been surmised that the *outer* ring of Saturn is divided into several smaller rings. Kater states, that he "saw the outer ring separated by numerous dark divisions extremely close, one stronger than the rest dividing the ring about equally." Such surmises, however, require to be confirmed by subsequent observations. It has been lately discovered that Saturn is environed with a third ring, of a somewhat dusky aspect. It was discovered at Cambridge, Massachussetts, U.S., Nov. 15th, 1850. It is interior to the two others, and therefore its distance from the body of Saturn must be comparatively small.

to contemplate. Such magnificent displays of wisdom and omnipotence lead us to conclude that the numerous splendid objects connected with this planet, were not created merely to shed their lustre on naked rocks and barren sands; but that an immense population of intelligent beings is placed in those regions, to enjoy the bounty and to adore the perfections of their great Creator.

The double ring of Saturn, when viewed through a good telescope, generally appears like a luminous handle on each side of the planet, with a dark interval between the interior edge of the ring, and the convex body of Saturn; which is owing to its oblique position with respect to our line of vision. When its outer edge is turned directly towards the earth, it becomes invisible, or appears like a dark stripe across the disk of the planet as it did in 1832. This phenomenon happens once every fifteen years.

The Planet HERSCHEL.—This planet, which is also known by the names of the *Georgium Sidus,* and *Uranus,* was discovered by Sir W. Herschel on the 13th of March, 1781. It is, with the exception of the newly-discovered planet Neptune, the most distant planet from the sun which is yet discovered; being no less than 1800 millions of miles from that luminary, which is nineteen times farther than the earth is from the sun—a distance so great that a cannon ball flying at the rate of 480 miles an hour would not reach it in 400 years. Its diameter is about 35,000 miles; and, of course, it is about eighty times larger than the earth. It appears like a star of the sixth magnitude; but can seldom be distinguished by the naked eye. It takes about eighty-three years and a half to complete its revolution round the sun; and, though it is the slowest moving body in the system, it moves at the rate of 15,000 miles in an hour. As the degree of sensible heat in any planet does not depend altogether on its nearness to the sun, the temperature of this planet may be as mild as that which obtains in the most genial climate of our globe.[1] The diameter of the sun, as seen from Herschel, is little more than the apparent diameter of Venus as seen by the naked eye; and the light which it receives from that luminary is 360 times less than what we experience; yet this proportion is found by calculation to be equal to the effect which would be produced by 248 of our full moons; and, in the absence of the sun, there are *six moons* which reflect light upon this distant planet, all of which were discovered likewise by Sir

[1] See Note, page 303.

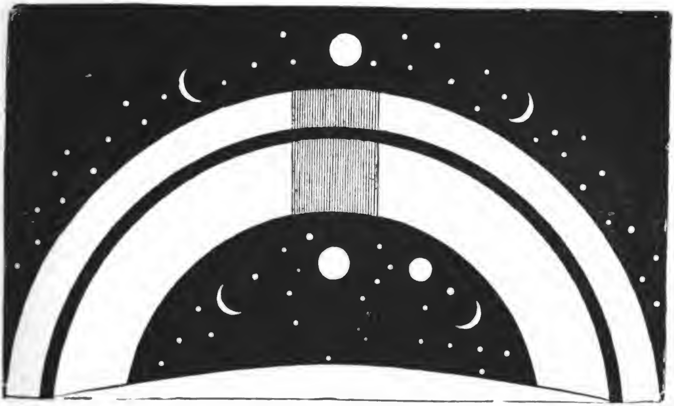
W. Herschel. Small as the proportion of light is which this planet receives from the sun, it is easy to conceive, that beings similar to man, placed on the surface of this globe, with a slight modification of their organs of vision, might be made to perceive objects with a clearness and distinctness even superior to what we can do. We have only to suppose, that the Creator has formed their eyes with *pupils* capable of a much larger expansion than ours; and has endued their *retina* with a much greater degree of nervous sensibility. At all events, we may rest assured, that He who has placed sentient beings in any region, has, by laws with which we are partly unacquainted, adapted the constitution of the inhabitant to the nature of the habitation.

> "Strange and amazing must the difference be
> 'Twixt this dull planet and *bright Mercury!*
> Yet reason says, nor can we doubt at all,
> Millions of beings dwell on either ball,
> With constitutions fitted for that spot
> Where Providence, all-wise, has fixed their lot."

The Planet Neptune.—The discovery of this planet forms a remarkable era in the history of astronomy. It was not discovered by observation, as was the planet Uranus and others, which have been detected in modern times; but its place in the heavens was found out by calculations founded on the principles of physical astronomy, and on the discrepancies which were found to exist between the observed and the calculated places of Uranus. It was conceived by some astronomers that probably some disturbing body existed beyond that planet, which had hitherto eluded the observation of astronomical observers, and which produced the irregularities to which we allude. The following is a short sketch of the history of this discovery:—

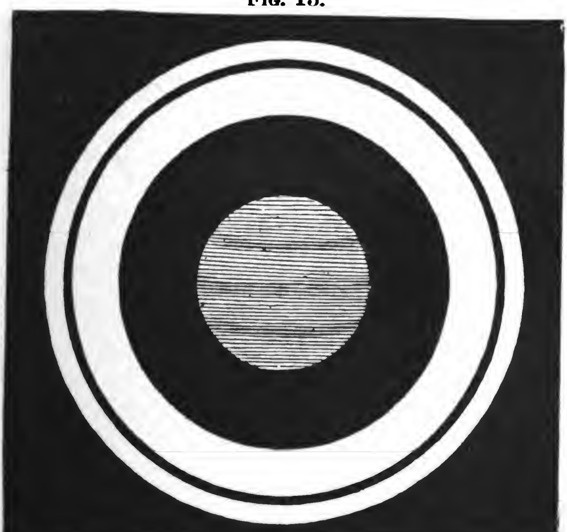
From the time of its discovery by Herschel till 1820, Bouvard, a French astronomer, noted down its tract in the heavens; but there appeared certain irregularities in its motions which could not be accounted for, and which gave rise to a number of conjectures.—In 1842, the late distinguished astronomer Bessel, in conversation with Sir J. Herscel, in reply to the question whether the deviation in question might not be due to the actions of an unknown planet, stated, that he thought it highly probable that such was the case. But, till September, 1843, there was not pro-

Fig. 12.



RINGS AND MOONS OF SATURN.

Fig. 13.



SATURN AND HIS RINGS.

duced by any astronomer a research that was calculated to decide the question. It was about this time that Mr. J. C. Adams, Fellow and Assistant of John's College, Cambridge, communicated to Professor Challis of the Cambridge Observatory, values which he obtained for the holiocentric longitude, eccentricity of orbit, longitude of perihelion, and *mass* of an assumed exterior planet deduced entirely from unaccounted-for perturbations of Uranus. The same results, somewhat corrected, were left at the observatory of Greenwich, about the end of the following October. These were the first intimations of the new planet that were ever made public, and at or near the position assigned above, it was afterwards seen by Professor Challis of the Cambridge Observatory. Had Mr. Airy attended to the above statements as he ought to have done, Mr. Adams would have enjoyed the undivided merit of being the first discoverer of the planet; and we cannot but feel indignant at the apathy and neglect of the Royal Astronomer, especially when we consider that Mr. Adams made two journeys to Greenwich to explain this matter, and left his papers and calculations at the observatory.

On the 1st of June, 1846—eight months after Mr. Adams had made known the elements of the new planet's orbit to the English astronomers—M. Le Verrier gave a memoir on the theory of Uranus, in which he affirmed the necessity of admitting the hypothesis of an exterior planet. No elements of its orbit or *mass* were given, but its longitude for the beginning of 1847, should be about 326°. He communicated his conclusions to the astronomers of the Berlin observatory on Sept. the 23rd, and guided thereby, and comparing the observations with a star map, H. Galle found the planet on the same evening.—Professor Challis, before this time, in consequence of a laborious research, had actually seen the planet, but had not published his observations. In fact, he had seen and recorded its position six weeks earlier than he who is considered as the real discoverer.

The planet NEPTUNE appears like a star of the eighth magnitude, and, consequently, may be seen with a moderate degree of magnifying power; but it will be difficult to distinguish it from small neighbouring stars, unless with a very high power, when a disk may be perceived. Its distance from the sun is reckoned about thirty times that of the earth, or 2,850,000,000, that is, two thousand eight hundred and fifty millions of miles, or more than a

X

thousand millions beyond the orbit of Uranus. Its *diameter* is reckoned to be about 50,000 miles. Of course, it is about 250 times larger than the earth, and three times larger than Uranus. Its revolution round the sun is reckoned to be accomplished in 166 years. Mr. Lassel of Starfield, near Liverpool, states, that soon after its discovery, he had different views of it, and believes that he may confidently assert, *that it is surrounded by a ring* like that of Saturn, placed three diameters from the body of the planet. Professor Challis and Mr. Morgan, his assistant, are also of opinion that Neptune is environed with a ring. It also appears that Neptune is attended by at least one satellite, which Mr. Lassel has several times seen. Its period of revolution is calculated to be five days, twenty hours, fifty minutes, forty-five seconds, and is about 250,000 miles distant from the planet.

The celestial globes I have described, are all the planets which are at present known to belong to the Solar system. It is probable that other planetary bodies may yet be discovered between the orbits of Saturn and Neptune, and even beyond that of the latter.

Comets—Besides the planetary globes to which I have adverted, there is a class of celestial bodies which occasionally appear in the heavens, to which the name of *Comets* has been given. They are distinguised from the other celestial bodies, by their ruddy appearance, and by a long train of light, called the tail, which sometimes extends over a considerable portion of the heavens, and which is so transparent that the stars may be seen through it. The tail is always directed tc that part of the heavens which is opposite to the sun, and increases in size as it approaches him, and is again gradually diminished, as the comet flies off to the more distant regions of space. Their apparent magnitude is very different: sometimes they appear only of the bigness of the fixed stars; at other times they equal the diameter of Venus; and sometimes they have appeared nearly as large as the Moon. They traverse the heavens in all directions, and cross the orbits of the planets. When examined through a telescope, they appear to consist of a dark central nucleus, surrounded by a dense atmosphere, or mass of vapours. They have been ascertained to move in long narrow *ellipses* or *ovals*, around the sun; some of them, on their nearest approach to him, having been within a million of miles of his centre; and then fly off to a region several thousands of millions of miles distant. When near the sun, they move with

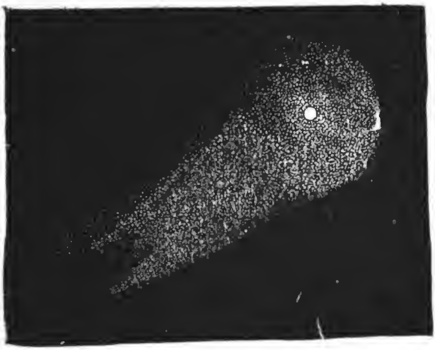
amazing velocity. The velocity of the comet which appeared in 1680, according to Sir Isaac Newton's calculation, was 880 thousand miles an hour. They appear to be bodies of no great density, and their size seldom exceeds that of the moon. The length of the tails of some comets has been estimated at 50 millions of miles. According to Sir W. Herschel's computations, the solid nucleus, or central part of the comet which appeared in 1811, was only 428 miles in diameter; but the real diameter of the head or nebulous portion of the comet, he computed to be about 127 thousand miles. The length of its tail he computed to be above 100 millions of miles, and its breadth nearly 15 millions. It was nearest to the earth on the 11th of October, when its distance was 113 millions of miles. The number of comets which have occasionally been seen within the limits of our system, since the commencement of the Christian era, is about 500, of which the paths or orbits of more than a hundred have been calculated.

As these bodies cross the paths of the planets in every direction, there is a possibility that some of them might strike against the earth in their approach to the sun; and, were this to happen, the consequences would be awful beyond description. But we may rest assured that that almighty Being who at first launched them into existence directs all their motions, however complicated; and that the earth shall remain secure against all such concussions from celestial agents, till the purposes of his moral government in this world shall be fully accomplished. What regions these bodies visit, when they pass beyond the limits of our view; upon what errands they are sent, when they again revisit the central parts of our system; what is the difference in their physical constitution, from that of the sun and planets; and what important ends they are destined to accomplish in the economy of the universe; are inquiries which naturally arise in the mind, but which surpass the limited powers of the human understanding at the present to determine. Of this, however, we may rest assured, that they were not created in vain; that they subserve purposes worthy of the infinite Creator; and that, wherever he has exerted his power, there also he manifests his wisdom and beneficence.

The periodical revolutions of the greater number of comets are accomplished only in long periods of time; some of them requiring hundreds and even thousands of years to finish their circuits. But, of late years, two comets have been discovered whose periodic

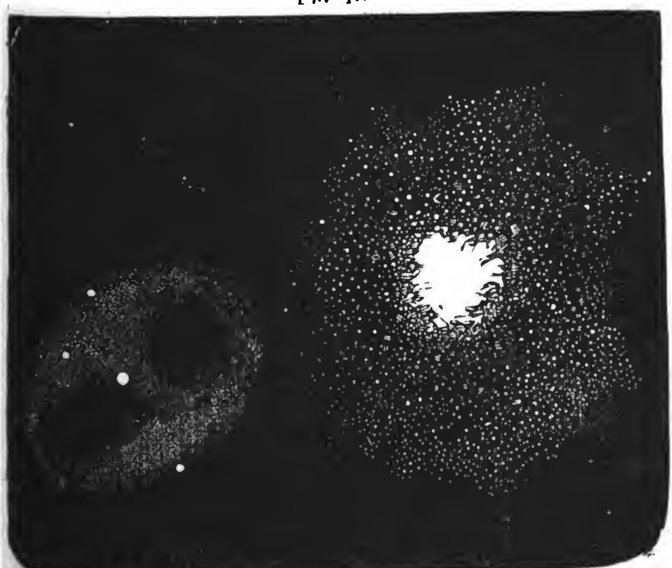
revolutions are extremely short.—These are, 1st, the *comet of Encke*, whose periodic revolution is only 1200 days, or three years and three-tenths, and becomes visible ten times in thirty-three years. It was discovered at Marseilles, by M. Pons, on the 28th November, 1818, and soon after M. Encke of Berlin determined its period by incontestable calculations. This comet has since regularly made its appearance. It was seen in Australia in June, 1822, and since that time in Europe, in 1825, 1828, 1832, 1835, and 1838. This comet is very small; its light is feeble; it has no tail, and it is invisible to the naked eye, except in very favourable circumstances.—The other comet to which we allude is distinguished by the name of *Biela's* and sometimes *Gambart's comet.* This comet was first perceived at Johanisberg, on the 27th of February, 1826, by M. Biela, and ten days after by M. Gambart, at Marseilles, who calculated its orbit, and determined the period of its revolution to be 2460 days, or nearly six and three-quarter years. The predicted appearance of this comet in 1832 produced considerable alarm on the continent, particularly in France; as some German journalists had predicted that it would cross the earth's orbit near the point at which the earth would be at that time, and cause the destruction of our globe. This comet is a small body without a tail, or any appearance whatever of a solid nucleus, and is not distinguishable by the naked eye. It is not improbable that the observations which may hereafter be made on these comets, whose return is so frequent, will lead to more definite and accurate views of the nature and destination of these singular bodies. The only other comet whose period is determined is that which is known by the name of *Halley's comet.* This comet was observed by Dr. Halley in 1682, and, on calculating its elements, he was led to conclude that it was identical with the great comets of 1456, 1531, and 1607; and that its period is seventy-five or seventy-six years. He accordingly ventured to predict that it would again return about the latter part of 1758 or the beginning of 1759. It actually re-appeared near the end of December, 1758, and arrived at its perihelion on the 13th March, 1759; and it again made its appearance, according to prediction, in September and October, 1835, having been seen in the particular positions previously predicted, a considerable time before it was visible to the naked eye. The appearance of this comet, so near the time predicted by astronomers, is a clear proof of the accuracy which has been introduced

FIG. 14.



HALLEY'S COMET.

FIG. 15.



NEBULÆ.

into astronomical calculations, and the soundness of the principles on which astronomers proceed. This circumstance likewise shows us that comets in general are *permanent* bodies belonging to that system of which we form a part.

Such is a general outline of the leading facts connected with that system to which our earth belongs. Though the energies of divine power had never been exerted beyond the limits of this system, it would remain an eternal monument of the wisdom and omnipotence of its Author. Independently of the Sun, which is a vast universe in itself, and of the numerous comets which are continually traversing its distant regions, it contains a mass of material existence, arranged in the most beautiful order, 2500 times larger than our globe. From late observations, there is the strongest reason to conclude that the sun, along with all this vast assemblage of bodies, is carried through the regions of the universe towards some distant point of space, or around some wide circumference, at the rate of more than 60,000 miles an hour; and if so, it is highly probable, if not absolutely certain, that we shall never again occupy that portion of *absolute space* through which we are this moment passing during all the succeeding ages of eternity.

Such a glorious system must have been brought into existence, to subserve purposes worthy of the Infinite Wisdom and Benevolence of the Creator. To suppose that the distant globes of which it is composed, with their magnificent apparatus of Rings and Moons, were created merely for the purpose of affording a few astronomers, in these latter times, a peep of them through their glasses, would be inconsistent with every principle of reason; and would be charging Him who is the Source of Wisdom with conduct which we would pronounce to be folly in the sons of men. Since it appears, so far as our observation extends, that matter exists only for the sake of sensitive and intelligent beings, and that the Creator made nothing in vain—it is a conclusion to which we are necessarily led, that the planetary globes are inhabited by various orders of intellectual beings, who participate in the bounty and celebrate the glory of their Creator.

When this idea is taken into consideration, it gives a striking emphasis to such sublime declarations of the Sacred Volume as these:—"All nations before him are as nothing—He sitteth upon the circle of the earth, and the inhabitants thereof are as grass-

hoppers—The nations are as the *drop of a bucket*—All the inhabitants of the world *are reputed as nothing* in his sight; and he doth according to his will in the armies of heaven and among the inhabitants of the earth—Thou hast made heaven and the heaven of heavens, with all their hosts; and thou preservest them all; and *the host of heaven worshippeth thee*—When I consider thy heavens, *what is man* that thou art mindful of him!" If the race of Adam were the principal intelligencies in the universe of God, such passages would be stripped of all their sublimity, would degenerate into mere hyperboles, and be almost without meaning. If man were the only rational being who inhabited the MATERIAL WORLD, as some arrogantly imagine, it would be no wonder at all that God should be "mindful of him;" nor could "all the inhabitants of this world," with any propriety, be compared to "a drop of a bucket," and be "reputed as nothing in his sight."—Such declarations would be contrary to fact, if this supposition were admitted; for it assumes that man holds the *principal station* in the visible universe. The expressions—"The heavens, the heaven of heavens," and "the host of heaven worshipping God," would also, on this supposition, degenerate into something approaching to mere inanity. These expressions, if they signify anything that is worthy of an inspired Teacher to communicate, evidently imply that the universe is vast and extensive, beyond the range of human comprehension—that it is peopled with myriads of inhabitants—that these inhabitants are possessed of intellectual natures, capable of appreciating the perfections of their Creator—and, that they pay him a tribute of rational adoration:—"The host of heaven worshippeth thee." So that the language of Scripture is not only consistent with the doctrine of a plurality of worlds, but evidently supposes their existence to all the extent to which the discoveries of modern science can carry us. However vast the universe now appears—however numerous the worlds and systems of worlds which may exist within its boundless range—the language of Scripture is sufficiently comprehensive and sublime, to express all the emotions which naturally arise in the mind when contemplating its structure; a characteristic which will apply to no other book or pretended revelation. And this consideration shows not only the harmony which subsists between the discoveries of Revelation and the discoveries of Science, but also forms, by itself, a strong pre-

sumptive evidence that the Records of the Bible are authentic and divine.[1]

Vast as the Solar system we have now been contemplating may appear, it is but a mere point in the map of creation. To a spectator placed in one of the stars of the seventh magnitude, not only the glories of this world, and the more resplendent scenes of the planet Saturn, but even the sun himself would entirely disappear, as if he were blotted out of existence. "Were the sun," says Mr. Addison, "which enlightens this part of the creation, with all the host of the planetary worlds that move about him, utterly extinguished and annihilated, they would not be missed by an eye that could take in the whole compass of nature, more than a grain of sand upon the sea-shore. The space they possess is so exceedingly little in comparison of the whole, that it would scarcely make a blank in creation."

THE FIXED STARS.—When we pass from the planetary system to other regions of creation, we have to traverse, in imagination, a space so immense, that it has hitherto baffled all the efforts of science to determine its extent. In these remote and immeasurable spaces are placed those immense luminous bodies usually denominated the *fixed stars*. The nearest stars are, on good grounds, concluded to be at least *twenty billions* of miles distant from our globe—a distance through which *light* (the swiftest body in nature) could not travel in the space of three years; and which a ball, moving at the rate of 500 miles an hour, would not traverse in four millions, five hundred thousand years, or 750 times the period which has elapsed since the Mosaic creation. But how far they may be placed beyond this distance, no astronomer will pretend to determine. The following consideration will prove, to those unacquainted with the mathematical principles of astronomy, that the stars are placed at an immeasurable distance. When they are viewed through a telescope which magnifies objects 1000 times, they appear no larger than to the naked eye; which circumstance shows, that though we were placed at the thousandth part of the distance from them at which we now are, they would still appear only as so many shining *points;* for we should still be distant from the nearest of them, 20,000 millions of miles: or, in other words, were we transported several thousands of millions of miles from the spot we now occupy, though their numbers would appear ex-

[1] See Appendix, Note VI.

ceedingly increased, they would appear no larger than they do from our present station; and we behooved to be carried forward thousands of millions of miles farther in a long succession, before their disks seemed to expand into large circles like the moon. Sir W. Herschel viewed the stars with telescopes magnifying from *one to two or three thousand times*, yet they still appeared only as brilliant points, without any sensible disks or increase of diameter. This circumstance incontestably proves the two following things: 1. That the stars are *luminous bodies*, which shine by their own native light; otherwise they could not be perceived at such vast distances. 2. That they are bodies of an immense size, not inferior to the sun; and many of them, it is probable, far exceed that luminary in bulk and splendour.[1]

For the convenience of reference to particular objects and regions in the heavens, the stars have been arranged into different groups and *constellations*. The number of constellations recognized by modern astronomers is about ninety-four; of which twelve are contained in the *Zodiac*, or that zone in the heavens in which the sun, moon, and planets, are seen to perform their real or apparent revolutions; thirty-five are reckoned *North* of the zodiac, and forty-seven to the *South*, called the *Northern* and *Southern* constellations. These constellations on celestial globes and planispheres, are generally depicted as if they were represented by various animals and hieroglyphic objects, which give such exhibitions of the heavens a very grotesque and *unnatural* appearance. We have therefore given, in fig. 16, p. 343, a representation of the constellation *Orion*, with the adjacent stars, on a more simple and *natural* plan, to show the manner in which the celestial constellations might be depicted on globes and planispheres, so as to make them resemble as much as possible their appearance in the heavens. This constellation makes a splendid appearance in the southern parts of the heavens during

1 Professor Bessel of Konigsberg appears to have ascertained the annual parallax of the star sixty-one *Cygni*, which he has determined to be somewhat less than *one third of a second*, and consequently its distance must be 62,481,500,000,000, or sixty-two *billions*, four hundred and eighty-one thousand, five hundred millions of miles—a distance which *light*, swift as its motion is, would require ten years and 114 days to fly across this mighty interval; and a cannon ball, moving 500 miles every hour, would require fourteen millions, two hundred and fifty thousand years before it could move across the same interval.—For a more detailed account of this discovery of Bessel, the reader is referred to the author's volume entitled 'Sidereal Heavens,' pp. 78—83.

our winter months. The two large stars near the top towards the left, are *Betelguese* and *Bellatrix*; the three equi distant stars, near the middle, are Orion's *belt*, called in the book of Job, the "*bands* of Orion." The large star, near the bottom, on the right, is *Rigel*, a star of the first magnitude. A white line is drawn around this constellation to define its boundaries, and, in this way the form and limits of all the other constellations might be distinguished.

The stars, on account of the difference in their apparent magnitudes, have been distributed into several classes or orders. Those which appear largest are called stars of the *first* magnitude; next to those in lustre, stars of the *second* magnitude, and so on to stars of the *sixth* magnitude, which are the smallest that can be distinguished by the naked eye. Stars of the seventh, eighth, ninth, and tenth, etc., magnitudes, which cannot be seen by the naked eye, are distinguished by the appellation, *telescopic* stars. Not more than 1000 stars can be distinguished by the naked eye in the clearest winter night; but by means of the telescope, millions have been discovered.[1] And as it is probable that by far the greater part lie beyond the reach of the best glasses which have been or ever will be constructed by man—the real number of the stars may be presumed to be beyond all human calculation or conception, and perhaps beyond the grasp of angelic comprehension.

In consequence of recent discoveries, we have now the strongest reason to believe, that all the stars in the universe are arranged into clusters, or groups, which astronomers distinguish by the name of NEBULÆ or STARRY SYSTEMS, each nebula consisting of many thousands of stars. The nearest nebula is that whitish space or zone which is known by the name of the *Milky Way*, to which our sun is supposed to belong. It consists of many hundreds of thousands of stars. When Sir W. Herschel examined this region with his powerful telescopes, he found a portion of it, only fifteen degrees long, and two broad, which contained *fifty thousand* stars large enough to be distinctly counted; and he suspected twice as many more, which, for want of sufficient light in his telescope, he saw only now and then. More than 3000 nebulæ have already been observed; and, if each of them contain as many stars as the Milky Way, several hundreds of millions of stars must exist, even

[1] See page 50.

within that portion of the heavens which lies open to our observation. Besides those Nebulæ which are resolvable into stars by telescopes, there are nebulous bodies in the heavens, of vast extent, such as the nebula in the sword of Orion, which the most powerful telescopes have hitherto been unable to resolve into stars. These are found in different degrees of condensation—from the resemblance of an irregular dusky cloud to the appearance of a well-defined body of faintish light, condensed to a bright spot in the centre. They appear to be a species of fine luminous matter, distinct from stars and planets, diffused in immense masses throughout the spaces of the universe. It is the opinion of many that these self-luminous portions of matter are the chaotic materials out of which new suns and worlds may be formed under the superintendence of Omnipotence—and that each mass of this substance is gradually concentrating itself by the effect of its own gravity, and of the circular motions of which it is susceptible—into denser masses, so as ultimately to effect the arrangement and establishment of sidereal systems.

In consequence of some recent discoveries, this opinion, which was carried to an extravagant extent by some, must now be received with considerable modifications, if not altogether discarded. Since the Earl of Rosse erected his large and powerful telescope, several new discoveries have been made in reference to some of the nebulæ here alluded to. On the night of the 5th March, 1845, the ring nebulæ in the Canes Venatici, or the fifty-first of Messier's catalogue, were resolved into stars, with a magnifying power of 548; and the ninety-fourth of Messier, which is in the same constellation, was resolved into a large globular cluster of stars. On subsequent nights observations were made on other nebulæ, amounting to thirty or more, which showed them all to be clusters of stars, and some of them presented most beautiful sidereal pictures. Since that period, even the great nebula in Orion, which had baffled Sir W. Herschel's best telescopes to resolve, has been partly resolved into stars, by the great telescope of the Earl of Rosse, which reflects far more than double the light of Sir W. Herschel's forty feet reflector.

It appears, from numerous observations, that *various changes* are occasionally taking place in the regions of the stars. Several stars have appeared for a while in the heavens, and then vanished from the sight. Some stars which were known to the ancients,

cannot now be discovered; and stars are now distinctly visible which were to them unknown. A few stars have gradually increased in brilliancy, while others have been constantly diminishing in lustre. Certain stars are ascertained to have a periodical increase and decrease of their lustre, sometimes appearing like stars of the first or second magnitude, sometimes diminishing to the size of the fourth or fifth magnitude, and sometimes altogether disappearing to the naked eye. The late discoveries respecting *double and triple* stars are particularly worthy of attention. Some stars which, to the naked eye, appear single, when examined by good telescopes, are found to consist of two, three, or more stars. In reference to *double stars*, one of the two is generally considerably smaller than the other, and it is now ascertained that, in many instances, the smaller star has a circular or elliptical motion around the larger. About 6000 double stars have already been detected; and between forty and fifty of these bodies have been ascertained beyond doubt to form revolving systems. Some of these require 1600, others 1200, and others about 452 years to complete their revolutions; while some others finish their circuits in the short periods of fifty-five, forty-three, and even thirty years. So that here we have *Suns* revolving around suns, and systems of worlds revolving around systems of worlds, in various combinations, throughout the tracts of immensity. It also appears that changes are taking place among the Nebulæ—that several nebulæ are formed by the decomposition of larger nebulæ, and that many nebulæ of this kind are at present detaching themselves from the nebulæ of the Milky Way. These changes seem to indicate, that mighty movements and vast operations are continually going on in the distant regions of creation, under the superintendence of the Sovereign of the Universe, upon a scale of magnitude and grandeur which overwhelms the human understanding.

To explore more extensively the region of the starry firmament; to mark the changes that are taking place; to ascertain all the changeable stars; to determine the periodical variations of their light; the revolutions of double and triple stars; and the motions and other phenomena peculiar to these great bodies—will furnish employment for future enlightened generations; and will perhaps form a part of the studies and investigations of superior intelligencies, in a higher sphere of existence, during an indefinite lapse of ages.

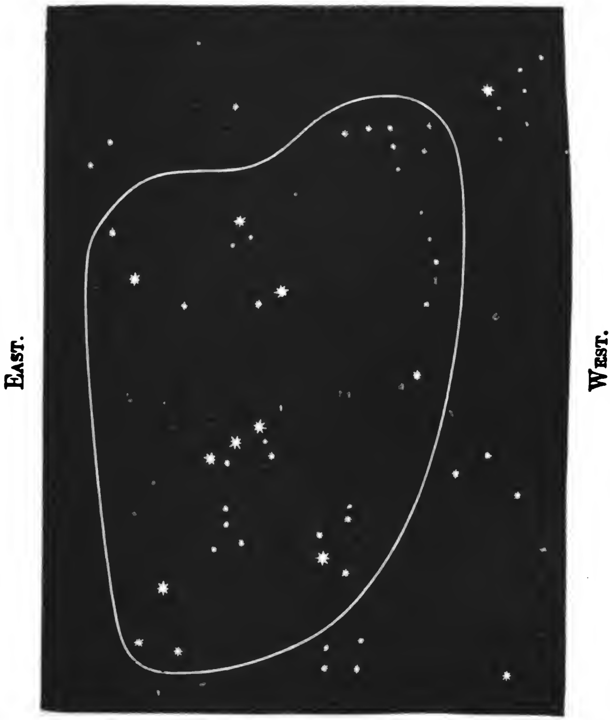
If every one of these immense bodies be a SUN, equal or superior to ours, and encircled with a host of planetary worlds, as we have every reason to conclude to be the case,[1] how vast must be the extent of creation! how numerous the worlds and beings which exist within its boundless range! and how great, beyond all human or angelic conception, must be the power and intelligence of that glorious Being who called this system from nothing into existence, and continually superintends all its movements! The mind is bewildered and confounded when it attempts to dwell on this subject; it feels the narrow limits of its present faculties; it longs for the powers of a seraph, to enable it to take a more expansive flight into those regions which "eye hath not seen;" and, while destitute of these, and chained down to this obscure corner of creation, it can only exclaim, in the language of inspiration, "Who can by searching find out God?—Great is our Lord, and of great power: his understanding is infinite!—Great and marvellous are thy works, Lord God Almighty!—Who can utter the mighty acts of Jehovah? who can show forth *all* his praise!"

After what has now been stated in relation to the leading facts of Astronomy, it would be needless to spend time in endeavouring to show its connection with Religion. It will at once be admitted, that all the huge globes of luminous and opaque matter to which we have adverted, are the workmanship of Him "who is wonderful in counsel, and excellent in working;" and form a part of the dominions of that august Sovereign, "whose kingdom ruleth over all." And shall it ever be insinuated, that this subject has no relation to the great object of our adoration? and that it is of no importance in our views of the Divinity, whether we conceive his dominions as circumscribed within the limits of little more than 25,000 miles, or as embracing an extent which comprehends innumerable worlds! The objects around us in this sublunary sphere, strikingly evince the superintendency, the wisdom, and benevolence of the Creator: but this science demonstrates, beyond all other departments of human knowledge, the GRANDEUR and MAGNIFICENCE of his operations; and raises the mind to sublimer views of his attributes than can be acquired by the contemplation of any other objects. A serious contemplation of the sublime objects which Astronomy has explored must therefore have a tendency to inspire us with profound veneration of the Eternal Jehovah—to humble us in the

[1] See pp. 43, 75.

Fig. 16.

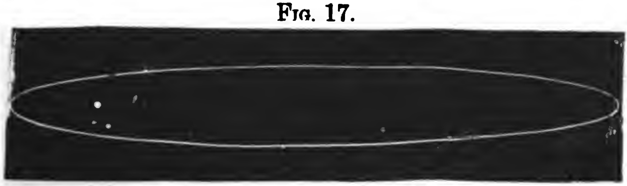
North.



South.

CONSTELLATION OF ORION.

Fig. 17.



ORBIT OF A COMET.

dust before his august presence—to excite admiration of his condescension and grace in the work of redemption—to show us the littleness of this world, and the insignificancy of those riches and honours to which ambitious men aspire with so much labour and anxiety of mind—to demonstrate the glory and magnificence of God's universal kingdom—to convince us of the infinite sources of varied felicity which he has in his power to communicate to holy intelligencies—to enliven our hopes of the splendours of that "exceeding great and eternal weight of glory," which will burst upon the spirits of good men, when they pass from this region of mortality—and to induce us to aspire with more lively ardour after that heavenly world where the glories of the Deity and the magnificence of his works will be more clearly unfolded.

If, then, such be the effects which the objects of Astronomy have a tendency to produce on a devout and enlightened mind, it forms a striking evidence of the depravity of man, as well as of his want of true taste, and of a discernment of what is excellent, that the grandeur of the nocturnal heavens, and the perfections of Deity they proclaim, are beheld with so much apathy and indifference by the bulk of mankind. Though "the heavens declare the glory of God," in the most solemn and impressive language, adapted to the comprehension of every kindred and every tribe, yet a brutish man knoweth not, neither doth a fool understand this." They can gaze upon these resplendent orbs with as little emotion as the ox that feeds on the grass, or as the horse that drags their carcases along in their chariots. Such persons must be considered as exposing themselves to that Divine denunciation:—"Because they regard not the works of Jehovah, neither consider the operations of his hands, he will destroy them, and not build them up." If the structure of the heavens, and the immensity of worlds and beings which they contain, were intended by the Creator to *adumbrate*, in some measure, his invisible perfections, and to produce a sublime and awful impression on the minds of all created intelligencies,[1] it must imply a high degree of disrespect to the Divinity, wilfully to overlook these astonishing scenes of power and intelligence. It is not a matter of mere taste or caprice, whether or not we direct our thoughts to such subjects, but an imperative duty, to which we are frequently directed in the word of God; the *wilful neglect* of which, where there is an opportunity of attending to it,

[1] See pp. 51, 52, 56.

must subject us to all that is included in the threatening now specified, if there be any meaning in language.

How very different were the feelings and the conduct of the sacred writers! They call upon every one of God's intelligent offspring to "stand still and consider the wondrous works of the Most High;" and describe the profound emotions of piety which the contemplation of them produced in their own minds: "Lift up your eyes on high, and behold! Who hath created these things? The heavens declare the glory of God, and the firmament showeth his handiwork. When I *consider* thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained; what is man, that thou art mindful of him? and the son of man, that thou visitest him? Thou, even thou, art Lord alone: thou hast made heaven, and the heaven of heavens, with all their host, and thou preservest them all; and the hosts of heaven worship thee. All the gods of the nations are idols; but the Lord MADE THE HEAVENS; Honour and majesty are before him. Jehovah hath prepared his THRONE in the heavens; and his kingdom ruleth over all.—Sing praises unto God, ye kingdoms of the earth, to him that rideth on the heaven of heavens. Ascribe ye POWER to our God; for his strength is in the heavens. Praise him for his mighty acts, praise him *according to his excellent greatness*."—If we would enter with spirit into such elevated strains of piety, we must not content ourselves with a passing and vacant stare at the orbs of heaven, as if they were only so many brilliant *studs* fixed in the canopy of the sky; but must "*consider*" them with fixed attention, in all the lights in which revelation and science have exhibited them to our view, if we wish to praise God for his mighty works, and "*according to his excellent greatness.*" And, for this purpose, the conclusions deduced by those who have devoted themselves to celestial investigations, ought to be presented to the view of the intelligent Christian, that he may be enabled to "speak of the glory of Jehovah's kingdom, and to talk of his power."

CHAPTER II.

Natural Philosophy.

The object of *natural philosophy* is to observe and describe the phenomena of the material universe, with a view to discover their causes, and the laws by which the Almighty directs the movements of all bodies in heaven and on earth. It embraces an investigation of the laws of gravitation, by which the planets are directed in their motions; the laws by which water, air, light, and heat, are regulated, and the effects they produce in the various states in which they operate; the nature of colours, sounds, electricity, galvanism, and magnetism, and the laws of their operation; the causes which operate in the production of thunder, lightning, luminous and fiery meteors, hail, rain, snow, dew, and other atmospherical phenomena. In short, it embraces all the objects of natural history formerly alluded to, with a view to ascertain the causes of their varied appearances, and the principles that operate in the changes to which they are subject; or, in other words, the laws by which the diversified phenomena of universal nature are produced and regulated. One subordinate use of the knowledge derived from this science, is, to enable us to construct all those mechanical engines which facilitate human labour and increase the comforts of mankind, and all those engines which tend to enlarge our views of the operations of nature. A still higher and nobler use to which philosophy is subservient, is to demonstrate the wisdom and intelligence of the Great First Cause of all things, and to enlarge our conceptions of the admirable contrivance and design which appear in the different departments of universal nature. In this view, it may be considered as forming a branch of *natural theology*, or, in other words, a branch of the religion of angels, and of all other holy intelligences.

The general object of natural philosophy being an investigation of the laws, the motions, and the phenomena of the material world, it may be expedient, before proceeding to describe its different departments, to give a brief sketch of some of the

General Properties of Matter.

We are placed in the midst of a scene where a vast variety of objects present themselves to our view, and solicit our attention. Whether we lift our eyes to the heavens, or look abroad on the surface of the earth, or descend into its subterranean recesses, we behold a vast multiplicity of materials and beings of various descriptions, animated and inanimated, of whose nature and properties, in the first instance, we have a very imperfect conception. We are furnished with a thinking principle, by which we are enabled to contemplate and classify the various objects which surround us, and to deduce conclusions respecting their properties and phenomena. This thinking principle, which we call *Mind*, is united to an organical structure, furnished with organs calculated to convey to the intellect impressions from every surrounding object as to its nature and qualities. These organs are the five senses, the organs of *seeing*, *hearing*, *feeling*, *tasting*, and *smelling*—through the medium of which alone we hold intercourse with the material world, and derive information respecting its diversified objects and appearances. Each organ is designed to convey to the mind immediate notice of some peculiar action or property in the objects around us, and accordingly is formed in a peculiar manner, and with a susceptibility corresponding to the nature of the notices it is intended to convey. The eye, for example, is intended to convey information respecting light, colour, shade, and the relative aspect and position of external objects; while the ear is chiefly intended to convey impressions of the various modifications of *sounds*. And, it is worthy of remark, that, each organ, however delicate its structure, is wholly insensible to every influence except that to which it is specially appropriated. Thus, the eye, which is so extremely susceptible to impressions from light, is not in the least affected by those of sound; nor is the exquisite mechanism of the ear at all affected by the most splendid emanations of light. The roar of thunders or of artillery may produce deafness, but it affects not the eye; and the

splendour of excessive light may cause blindness to ensue, but it produces no injury to the organ of hearing; and so it is with regard to the other senses.

These senses, then, are the instruments or medium by which the spiritual principle in man is enabled to perceive the existence of the various objects which surround us, and the properties with which they are invested. From this source all the elements of our knowledge, of whatever description, are originally derived—and without such senses we can have no conceptions how a knowledge of the material world could be acquired. The two *substances* which exist in the universe are *Matter* and *Spirit*. Of spirit we can know nothing *directly* through the medium of the corporeal senses; but these senses furnish the materials on which mind or spirit operates; and when the phenomena and arrangements of the material universe are properly contemplated and investigated, the existence of *mind*, or a principle distinct from matter, is a natural and necessary inference. But it is to matter chiefly, and its qualities as discovered by the senses, that the investigations of natural philosophy relate.

It is one of the first steps of natural science to ascertain the laws and properties of the various bodies which surround us, and all human beings are engaged, in a greater or less degree, in this study. As soon as a child begins to exercise its senses on the objects of the material world, it becomes, from that moment—in a subordinate sense—a natural philosopher. Hence we find that a principle of curiosity, and a desire for information respecting every surrounding object, is implanted in the infant mind as a stimulus to the prosecution of knowledge; and hence the eager desires manifested by the young to examine with minute attention every new object presented to their view, and to ascertain all its parts and properties. This study of natural science, however, is very circumscribed in the case of the greater part of mankind. They observe the qualities of natural substances chiefly in relation to their mechanical employments and domestic arrangements, or the influence they may have on their sensitive enjoyment. Whereas the true natural philosopher enters into minute and deep investigations of the properties of bodies—examines them in all their diversified modifications—inquires into the causes of their varied phenomena—takes a large and comprehensive view of all the scenes of the material universe, and applies the discoveries he

may make, and the powers and principles he may ascertain as existing in the natural world, to the improvement of the useful arts, and for explaining the causes which operate in producing the general phenomena of nature. He does not rest satisfied with collecting a confused heap of insulated facts; but by the faculty of *generalization*, compares, classifies, and arranges them, so as to establish science on a regular basis, and to promote its progressive improvement—without which no real or useful advancement in knowledge could be promoted.

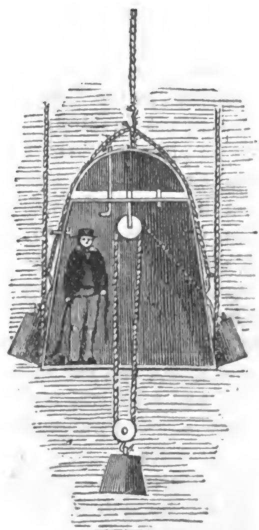
Having made these general remarks, we may now attend to a few of the general properties of material substances.

It is not easy to give an accurate definition of *matter*. It is the name given to every substance that has length, breadth, and thickness; or it is that substance which, in all its different forms and modifications, becomes the object of our five senses, and hence, also, the object of the investigations of natural philosophy. Here we must be understood to mean not only what the senses really perceive, but those things which by their nature they are *capable* of perceiving. Thus, for example, the animalcules in water are objects of sight although we are obliged to use a microscope in order to discover them. It is the same with the objects of hearing, taste, touch, and smell; these objects may be withdrawn from our sensations by their *minuteness*, not by their *nature*, and may possess the qualities of matter, though our senses are not sufficiently *acute* to be affected by them. Thus the magnetic and electric fluids are not perceived by our senses, though they are productive of certain physical phenomena, and therefore may be reckoned objects of sensation, and a part of the material world.—The following are some of the *general properties common to all matter*:—

1. Extension is that portion of universal space which a body occupies. This is an essentially constituent property of matter; and upon this property the form and the size of the body depend. This property is observable by the senses in all bodies which are not so minute as to elude them, and which the understanding can trace to the smallest particle of matter. It is impossible by any stretch of imagination, even to conceive a portion of matter so minute as to have no magnitude or extension. The quantity of space occupied by a body is called its *size, magnitude*, or *volume*. Thus the volume of space occupied by the earth is about 264

thousand millions of cubic miles, and the volume occupied by a room twenty feet long, fifteen broad, and ten high, is 3000 cubic feet. All bodies are extended, either into length only, and then it is called a *line*—or into length and breadth, which is called a *superficies;* or into length, breadth, and depth, which is then called a *solid.* These are the dimensions according to the quantity of which, the magnitude or extension of bodies is estimated.

2. IMPENETRABILITY, or what is sometimes termed SOLIDITY. It is that property in consequence of which two bodies cannot occupy the same place at the same time.—If a piece of wood or metal occupy a certain space, before any thing else can take possession of that space, the wood or metal must be removed. Water and even air have this property. For, if some water be put into a tube closed at one end, and a piece of wood be inserted that fits the inside of the tube very accurately, it will be impossible by any force to get the wooden piston to the bottom of the tube, unless the water be first taken away. The principle of the Diving Bell shows the impenetrability of the *air;* for the air in the bell prevents the admission of water into it when it is immersed in the sea; and hence water, air, and all other fluids are, with reference to space, equally impenetrable as the hardest substanees. One of the most striking illustrations of the impenetrability of matter, and at the same time of the great incompressibility of water, is afforded by Bramah's hydrostatic press. When bodies, then, are said to be impenetrable, it is meant that one cannot pass through another without displacing some or all of the component parts of that other. There are indeed some instances of *apparent* penetration; but in such cases the parts of the body which *seem* to be penetrated are only displaced. Thus, for example, if the point of a bodkin, or a piece



SECTION OF A DIVING BELL.

of brass wire be plunged into a vessel of water, the wire or bodkin may *seem* to penetrate the water; but the fact is, that all the water which previously filled the space into which the wire entered will be displaced, and the level of the water will rise in the vessel to the same height, as it would do by pouring in so much more water as would fill the space occupied by the wire.—If impenetrability, as now considered, was not an *essential property* of matter, the material world would vanish from the eyes of the understanding, and we could have no distinct notion of it. For as soon as matter exists, it must be viewed as impenetrable: this is the first thing that constitutes its existence as matter, or as a part of the physical world.

3. FIGURE is another property which necessarily flows from the preceding definitions, or rather from the very existence of matter itself. Whatever is material must have figure or shape. For since matter is not infinite, it must be circumscribed within certain limits on every part, which constitute the figure of the body; and as the particles of matter may exist together in any mode of arrangement, so the figures or forms of bodies which they compose may be almost infinitely various and different from each other. When we place our hand upon a solid body, we are sensible it has certain determinate limits—that these limitations are placed in certain directions relatively to each other—and that the mutual relation which is found to subsist between these boundaries of a body, gives us the notion of its *figure*. It is proper, however, to distinguish between the *figure* and the *volume* of a body. Bodies may have the same figure, and have very different volumes. A globe, for example, may have ten times the volume, or *size*, of another globe, and yet have the same figure, and two bodies, such as a die and a sphere, may have figures altogether different, and yet have equal volume, or contain the same number of cubical inches or miles.

4. DIVISIBILITY.—Divisibility is the property by which a body can be divided into separate and distinct portions. Whether matter be *infinitely* divisible, is a question about which philosophers have differed in opinion. It has been attempted to prove mathematically that matter is divisible to infinity, but the reasoning by which this position is attempted to be supported is merely ideal, and only shows that we can *conceive* extension to be infinitely divisible. To the practical subdivision of matter, however, there seems

to be no assignable limit. Numerous examples of the division of matter, to a degree almost exceeding belief, may be found in the experiments connected with physical science, and in the operations of the useful arts, of which the following may be stated:—

If a pound of silver be melted with a single grain of gold, the gold will be equally diffused through the whole silver; so that taking one grain from any part of the mass—in which there can be no more than the 5760th part of a grain of gold—and dissolving it in aqua fortis, the gold will fall to the bottom, showing the extreme divisibility of the substance of gold.—Again, a grain of gold may be hammered by the gold beaters into a leaf containing fifty square inches, and this leaf may be divided into 500,000 visible parts. And if one of these parts be viewed with a microscope magnifying only ten times in diameter, it will magnify the area one hundred times, and then the *fifty-millionth* part of a grain will be visible. Such are the leaves commonly used in gilding, and they are so very thin that if 360,000 of them were laid upon one another and pressed together they would not exceed one inch in thickness. Dr. Wollaston, by a certain process, succeeded in obtaining Platinum wire, so small that the diameter of it did not exceed the *one-hundred-and-eighty-thousandth part* of an inch. It was computed that a quantity of this wire equal in bulk to a common die used in games of chance, would extend from Paris to Rome, or nearly six hundred miles. Such is the extreme fineness and tenacity of spider's thread, that a quantity of it weighing only two grains, would reach from London to Edinburgh, a distance of between four and five hundred miles. The transparent wings of certain insects are so attenuated in their structure that fifty thousand of them placed over each other would not form a pile a quarter of an inch in height. The extreme minuteness into which some bodies may be divided is strikingly illustrated in certain colouring substances, particularly *carmine*, which is a kind of powder obtained from the insect named *cochineal*. If a small quantity of this powder, not exceeding the weight of three-fourths of a grain, be put into the bottom of a vessel, into which, is afterwards poured thirty pounds of water, the colour will be so diffused as to be perceptible throughout the whole volume of the water, and by calculation it is found that, in this case, there must be *three millions* of visible parts in three-fourths of a grain of carmine.

The impressions made upon the sense of smelling likewise

demonstrate the extreme divisibility of which matter is susceptible. It is agreed by philosophers, that odours arise from effluvia proceeding from the odoriferous bodies, which are disposed on every side, throughout the circumambient medium, and which rush upon the olfactory nerves by means of the air we draw into our nostrils; and hence it follows, that in whatever place the odour of any body is sensible, there must be in that place some particles of the odoriferous body. There are bodies whose weight is scarcely sensibly altered after a long interval of time, during which all those who are found within a certain distance incessantly experience the action of the odoriferous particles emanated from the substance of these bodies. There is a substance, taken from a bag contained in the body of a certain animal, to which the name of *musk* has been given. It is found that a single grain of this substance will send forth a strong odour, during a number of years, in an apartment into which fresh air is frequently admitted. The simple friction of a paper in which a small portion of this substance has been wrapped will suffice to make a habit impart a fragrant smell for several days. How immensely numerous, then, must be the particles of effluvia continually emitted by this odoriferous substance! As there are many odoriferous bodies which affect the olfactory nerves at the distance of five feet, there must be some particles of an odorous body diffused throughout all that space. Taking this for granted, and supposing that there is but one particle of the odorous body in every part of that space, which part shall be equal to the fourth part of a cubic inch—Dr. Keil has calculated that in a sphere whose semidiameter is five feet, there will be 57,839,616, that is fifty-seven millions, eight hundred and thirty-nine thousand, six hundred and sixteen such spaces; and, consequently, so many will be the particles producing the odour in that space. By another calculation, in order to discover the *magnitude* of a particle of the effluvia proceeding from *assafœtida*, he found that each particle was equal to only 1,250,000,000,000,000, that is less than the one-thousand-billionth part of a cubic inch.—These calculations proceed on the supposition that a man is able to smell *assafœtida* at the distance of five feet; but there are other animals whose sense of smelling is far more acute than that of man, as hounds, that perceive the effluvia of wild beasts a considerable time after the animal has left its place; and therefore the subtility of such effluvia must be much greater than what has been now stated.

The divisibility of matter may also be illustrated from examples taken from the organized and living world. There are found in various liquids *animalcules* so small that they appear only like points when viewed through microscopes magnifying several hundreds of thousands of times. The smallness of some of these animalcules is such that a million of them do not exceed the bulk of a grain of sand; and yet each of these creatures is composed of members as curiously organized as those of the larger animals. They have life and spontaneous motion—are endued with sense and instinct—are observed to move with astonishing speed and activity—and their motions appear evidently to be governed by choice and directed to some end. They take food and drink, and are consequently furnished with organs of digestion. They appear to have considerable muscular power, and are furnished with limbs and muscles of strength and flexibility. We must therefore conceive that these living beings have a heart, arteries, veins, muscles, and circulating fluids, with all the other parts and organs requisite to constitute an animated being. And if this be admitted, how inconceivably fine and minute must such organs be! Dr. Keil has calculated that the bulk of one of these animalcules—by no means the smallest—is equal to only 27-1,000,000,000,000,000ths, or less than the forty-billionth part of a cubic inch; that is, it would require more than forty billions of such minute beings to be equal in size to a cubic inch. Hence what some philosophers have dreamed concerning angels is true of these animalcules, namely, that many thousands of them may dance on the point of a small needle. And if the bodies of these animalcules be so small, how inconceivably smaller must be the globules that swim in their blood! In the human species the diameter of the globules of blood is reckoned about the four-thousandth part of an inch. And if the globules of the blood in these animalcules be in the same proportion to their bulk, as the globules of a man's blood bears to his body, it is found by calculation that the magnitude of these globules will be less than one 1,000,000,000,000,000,000,000,000,000,000,000th, or a thousand quintillion parts of a cubic inch. And further, that, 125,000,000,000,000,000,000,000,000, or one hundred and twenty-five quartillions,[1] is less than the number of blood globules

[1] For the information of the unlearned reader, it may be stated that a Million contains ten hundred thousand units; a Billion contains ten hundred thousand millions; a Trillion, ten hundred thousand billions; a

that may be contained within the magnitude of a grain of sand. It is calculated that the number of grains of sand that may be contained in the mountain Teneriffe—which ranks among the highest mountains on the globe—is 12,187,500,000,000,000,000,000. Now, if the former number be divided by this, the quotient will be somewhat more than 10,256, which shows that one grain of sand may contain ten thousand, two hundred and fifty six times more blood globules in it than one of the highest mountains does grains of sand.

These and other phenomena in nature, which might have been specified, prove that the materials of which bodies are formed are susceptible of being divided into a degree of minuteness, which is wonderful beyond measure, and which far exceeds the human understanding, even when aided by all the discoveries of science, fully to comprehend or explore.—If light be a material substance emitted by luminous bodies, its subtility must be inconceivably greater than any of the examples we have yet stated. For the light which emanates from the smallest candle, will, in an instant, fill a sphere four miles in diameter, without the least discernible diminution of the candle; for its light may be perceived by any eye within the distance of two miles, and consequently, the whole sphere of four miles in diameter must be filled with particles of light. The number of particles of light which fill such a space can scarcely be represented by any numbers to which the mind of man can attach an adequate idea, while chained down to its present limited sphere. In every portion of his works the operations of the Creator are incomprehensible, whether we contemplate the amazing magnitude of the magnificent orbs which roll around us in the sky, or the no less amazing minuteness of the particles of matter which form the body of an animalcule a million of times less than a grain of sand. "There is none like unto thee, O Lord! neither are there any works like unto thy works." "Thou dost great things past finding out, and wonders without number."

The properties we have illustrated above are those which are considered as essential to the existence of matter, and which all

Quartillion, ten hundred thousand trillions, etc. A quartillion contains a series of twenty-five figures, thus, 1,000,000,000,000,000,000,000,000.

bodies in the universe possess in a greater or less degree. Besides these, matter possesses a great variety of other properties more or less essential to the actual constitution of the material world—which we may very briefly notice.

1. Mobility.—This is a property possessed by a body of being capable of transportation from one place to another. It is found, from experience and observation, that all matter is capable of being moved, if a sufficient force can be applied for the purpose. That state which is called *motion* supposes the action of a cause, to which has been given the name of *force* or *power*. That this cause may exist, it is not necessary that the bodies which it solicits should be in actual motion. Thus, when two bodies make an equilibrium at the extremities of the arms of a balance, they are maintained in that state by forces really existing, but whose effects mutually destroy each other, so as to prevent the production in either body of any tendency to move.—Motion is *uniform* when the moving body always describes the same space in the same time. When the velocity is always equally augmented in equal times, the motion is said to be *uniformly accelerated*. When, on the contrary, it is always diminished by equal quantities, in equal times, the motion is said to be *uniformly retarded*. *Absolute motion* is the change of absolute place. *Relative motion* is the change of situation. The real and absolute motions of bodies are detected by means of observations made on their relative motions.

Our senses do not testify the absolute motion or absolute rest of any body. When one body removes from another, this may be discovered by the senses; but whether any body keeps the same part of absolute space, we do not perceive by our senses. When one body seems to remove from another, we can infer with certainty that there is absolute motion; but whether in the one or the other, or partly in both, is not discernible by our senses. A man sitting in a barge in motion is relatively at rest, that is with respect to the parts of the barge, but absolutely in motion, being removed with the vessel from one part of space to another. On the contrary, the bargeman, who fixes a staff in the ground and gives motion to the barge, by walking along the gunwale, is absolutely at rest; for the staff against which he leans is fixed; but relatively in motion, since, with respect to the barge, he walks from one end to the other. But if the earth be supposed in motion, the absolute motion of the

barge and its contents will be compounded of its relative motion together with the absolute motion of the earth.

It is chiefly by means of motion that the numerous operations of nature, both in the heavens and on the earth, are carried on and displayed to our view. Without motion, all the variety, beauty. and ornament of the universe would be destroyed, and an unvaried scene of dull uniformity would appear over the whole face of nature. On motion depend the alternate succession of day and night—the varying aspect of the starry heavens—the return of comets and eclipses—the revolutions and the relative positions of the planets—the flux and reflux of the tides—the alternations of cold and heat—the descent of rain and dews—the different lengths of days and nights—and the vicissitudes of the seasons which diversify the revolving year.—It is by motion that trees and plants grow, and that the sap is conveyed and circulated through every branch, leaf, and flower, for the nourishment of all the vegetable tribes, and to preserve them in beauty and verdure. It is by motion, under the direction and superintendence of the Creator, that man and other animals "live and move and have their being." For life itself consists chiefly of motion. The incessant circulation of the blood, with its immense velocity, through hundreds of veins and arteries, preserves the animal machine in existence and vigour, while the heart beats in the centre of the system to keep the machine in motion, and thousands of lacteal and lymphatic tubes absorb and convey nourishment to the. circulating fluid. Before we can breathe, or feel, or walk, an immense multiplicity of moving machinery must be in action, every part of which contributes to the sustentation of life and to the promotion of its enjoyments. In short, it is motion that gives life, animation, and happiness to all beings throughout the amplitudes of creation—that connects together all the vast systems of the universe—that preserves them in harmony and order—and, under the direction of Infinite Wisdom, renders stable and permanent the universal empire of Jehovah.

2. Inertia, or Inactivity, is that property of matter by which it would always continue in the same state of rest or of motion in which it is put, unless changed by some external force. It is one of the earliest and most universal results of human observation that matter is incapable of spontaneous change. It is just equivalent to

saying that mere matter is destitute of life; for spontaneous action is the only test of the presence of the living principle. When we see a mass of matter undergoing change, we never seek for the cause of that change in the body itself, but in some external cause producing it. A body cannot, of itself, commence to move from a state of rest, independent of all external influence, nor can it, when moving, arrest its progress without an external cause. A stone, for example, can never put itself in motion, unless it be, in some way or other, acted upon. Bodies in motion, as a bowl on the ground, or a cannon ball passing through the air, fall from motion to a state of rest, not by any energy in themselves, but either by the friction of the earth, by the effect of gravity, or by the resistance of the air. A bowl moves but a short way upon a bowling-green, because the roughness of the grassy surface quickly creates friction enough to stop it. But if the green were covered with polished glass, and extended quite round the earth, and the resistance of the air taken away, and the bowl itself perfectly hard, round, and smooth, it would move round the earth without interruption, and continue in that state for ever. If a ball were carried several miles above the surface of the earth, and projected with a certain degree of velocity in a horizontal line, and if there were no resistance from the air, it would circulate round the earth perpetually with the same velocity it at first received. In this manner the moon—which is a body as inert as a stone or ball—perpetually revolves round the earth from one year and century to another, having no power to stop its course, unless an external cause was to intervene. That motion, when unresisted by any obstacle or external cause, will for ever continue, we have exemplified, on a magnificent scale, in the heavens. Removed from all causes and impediments that would obstruct their motions, the mighty globes of the universe roll on in their appointed courses with unerring regularity, preserving, from age to age, all that motion which they received from the hand of the Almighty Creator when he first formed and launched them through the regions of space.

The following are some examples of the law of inertia:—If a carriage or a boat, moving with rapid velocity, be suddenly stopped, the passengers will be precipitated in the direction of the motion; because, by reason of their inertia, they persevere in the motion which they shared in common with the vehicle which transported them, and are not deprived of that motion by the cause which interrupted

the vehicle. Again, "if a passenger leap from a carriage in rapid motion, he will fall in the direction in which the carriage is moving at the moment his feet meet the ground; because his body, on quitting the vehicle, retains, by its inertia, the motion which it had in common with it. When he reaches the ground this motion is destroyed by the resistance of the ground to the feet, but is retained in the upper and heavier part of the body; so that the same effect is produced as if the feet had been tripped."

Some persons may be apt to imagine that living beings, such as man and other animals, form exceptions to the law of inertia. But we ought to consider that all the parts which constitute the organs and members of the living machine are in themselves inert bodies, and are subject to the same laws as all the other species and forms of matter. They derive their power of action from the principle of animation, and not from any inherent property which exists in the several parts. Hence, when the principle of life is removed by death, voluntary action and motion no longer remain, even although no particular derangement appears to exist in the once living being. And this leads us to conclude that the principle of spontaneous and voluntary motion, in all living organized beings, is altogether different from mere matter, and is not subject to those laws by which matter is recognized and governed. It must be the result of the action of a spiritual or immaterial principle, which directs and governs the actions of all organized bodies. In like manner, when we contemplate the operations and movements that are going forward in this lower world, and particularly when we consider the motions and phenomena of the celestial orbs, we must necessarily conclude that an immaterial principle at first formed and set in motion those vast bodies, and incessantly conducts and superintends them in all their movements. And this spiritual agent is no other than the self-existent and eternal Jehovah, whose power is omnipotent, whose wisdom is unsearchable, and "whose kingdom ruleth over all."

3. Attraction.—By attraction is meant the tendency which bodies have to approach each other, whatever may be the cause of such tendency. There have generally been distinguished *five* kinds of attraction—the attraction of *cohesion*—of *gravitation*—of *electricity*—of *magnetism*—and of *chemical affinity*. The attraction of *cohesion* is that by which the constituent particles of bodies are kept together, in consequence of which they preserve their forms,

and are prevented from falling to pieces. This species of attraction takes place between bodies or atoms, only when they are at very small distances from each other. The following experiments will illustrate this species of attraction. If two globules or drops of quicksilver be placed near each other, they will run together and become one large drop. If two pieces of lead be scraped clean, and pressed together with a twist, they will attract each other so strongly as to require a force much greater than their own weight to separate them. If two leaden balls be finely planed with the edge of a sharp pen knife, and squeezed together with a gentle turn of the hand, they will adhere so firmly as to require a considerable force to separate them. Mr. B. Martin mentions that, with two balls not weighing above a pound each, nor touching upon more than 1-30th of a square inch surface, he has lifted above two hundred pounds weight.—If a small glass tube, open at both ends, be dipped in water, the water will rise up in the tube to a considerable height above its level in the basin, and the smaller the bore of the tube the higher will the water rise. On the same principle, a piece of loaf sugar will draw up a fluid, and a sponge will draw in water, and on the same principle sap ascends in trees.—This last kind of cohesion is frequently called *capillary attraction.*

Electrical Attraction. Several bodies, such as glass, amber, sealing wax, jet, and most precious stones, have a peculiar property of attracting and repelling light bodies, when excited by rubbing—which property is distinguished by the name of *electrical attraction.* If a pretty thick glass tube, two or three feet long, be rubbed rapidly by the hand or a piece of flannel, it will alternately attract and repel light bodies, when held near them, such as straws, feathers, hair, leaf brass, and similar substances. If a large stick of sealing wax be rubbed in this manner, it will produce a similar effect. Any light body repelled by the wax or tube will not be attracted again till it has touched some other body. The electric power is most fully exhibited by a large cylinder fitted up as an electrical machine. It is a principle which pervades most bodies, which produces its effects with amazing rapidity, and performs a variety of wonderful and important functions in the system of nature.

Magnetic Attraction is that which is produced by the loadstone on iron and steel. If a few needles or pieces of iron be brought within a certain distance of a loadstone they will rush towards it, and it will require a certain degree of force to separate them. Of

the properties of this attractive power, we shall exhibit some specimens, under another department of Natural Philosophy.

Attraction of Gravitation is that power by which distant bodies tend toward each other. By this power in the earth it is that bodies, on whatever side of the globe, fall in lines perpendicular to its surface, because the point towards which they ultimately tend is the centre of the earth; and by this power it is that all bodies over the surface of our globe are kept to it on all sides, and prevented from flying off to the distant regions of space. If two bodies which contain equal quantities of matter, such as a mass of clay or a mass of metal, were placed at a distance from each other in the abyss of space, without any other body to produce an influence upon them—they would fall with an equal velocity towards each other by the power of gravitation, with velocities accelerated as they approach each other, and would meet in a point half-way between their original positions. This power decreases in proportion to the square of the distance; that is, a body at twice the distance of another, attracts with only a fourth part of the force; at thrice the distance with a ninth part, at four times the distance with a sixteenth part, etc.

It is by the power of gravitation that the moon is carried in its course round the earth, and that the planets are preserved in their respective orbits in their revolutions round the sun. It is the grand principle which unites the sun with the surrounding planets —the satellites with their primaries—the different systems of creation with each other, and produces beauty and harmony throughout the universe. Without the agency of gravitation, and the other species of attraction to which we have adverted, the whole face of nature would be deprived of variety and beauty—the universe would become a confused mass of atoms without form, shape, or motion, dispersed through boundless space—organized beings could have no existence--no portions of matter would have a tendency to change their position—and all would be a state of eternal stillness and rest.

Chemical Attraction, or affinity, is that species of attraction which operates at insensible distances, and unites the particles of different bodies so intimately as to produce a uniform whole which cannot be separated by any mechanical efforts.—This species of attraction may be exemplified as follows:—Sand and salt, exposed to a strong heat, combine by this law and form glass. In this case it

is an uniform whole, which no mechanical forces can again separate into sand and salt; and the properties of glass are not only different from those of sand and salt, but in many respects contrary to them.—If a rod of bright gold be immersed in mercury, and taken out, it will be found that the gold has drawn up a coating of mercury which cannot be wiped off; the gold is rendered white; and although the surface were scraped till the whiteness were removed, a separation is not effected; the scrapings contain both gold and mercury.—If we melt together equal quantities of tin and iron, two malleable and ductile metals—the compound produced will have totally lost the properties which its constituent parts possessed before their union; for the alloy formed will be a very *brittle* metal. If liquid ammonia and muriatic acid—both fluids of a strong odour—be mixed in proper proportions, a fluid will be produced entirely devoid of smell, namely, muriate of ammonia. If nitrate of ammonia and sulphate of soda, both in crystal, be rubbed together in a stone mortar in equal proportions, the mixture will be converted into a fluid. The above are examples of chemical attraction, in which the particles of different bodies unite with each other, and form a new compound. A lump of sugar dissolved in water is also an example of this kind of attraction.

Such are some of the different kinds of attractive powers generally distinguished by philosophers. Whether they all proceed from the same general cause, or are different modifications of the same principle, we do not pretend to determine. Nor do we presume to define or to determine what the original cause is, but simply that a cause exists—and that it is governed in its action by certain laws.—One truth, however, is unquestionable, and that is, that the attractive powers and other properties to which we have adverted were originally communicated to all matter by the Wisdom and Omnipotence of the Deity to accomplish important ends in the economy of the universe; and we cannot sufficiently admire the energy of that Almighty Being who had wisdom to contrive, and power to endue the matter he had formed with the astonishing power of operating upon his fellow matter, either when in contact, or when separated from it hundreds of millions of miles. Yet without such powers and properties in matter the universe could not have existed in its present state.

Without specifying any additional properties of matter, I shall just state the following

Laws of Motion.

1. Every body continues in its state of rest, or of uniform motion in a right line, unless compelled to change that state by forces impressed. For matter at rest being endued with no power of moving itself, would remain so for ever, unless impelled by some external cause: and we have many proofs that a body in motion will continue to move uniformly in a right line unless prevented by some other agents; but the motion of all projectiles connected with the earth is destroyed by the force of gravity and the resistance of the air.

2. All change of motion is in proportion to the force impressed, and is made in the line of direction in which that force is impressed. If any force produces motion, a double force will produce a double quantity, and a triple force, a triple quantity, whether it be impressed all at once, or by successive impulses.

3. Action and re-action are always equal and contrary; or, the mutual actions of two bodies are always equal, and in contrary directions.

Thus, if a stone be pressed by the finger, the finger is equally pressed by the stone. If a horse draws a stone, the stone draws the horse equally backwards, for the rope is equally stretched towards both. If one body impels another it will itself suffer an equal change of motion, by the re-action in a contrary direction. In magnetic attractions, we find that the loadstone does not only draw the iron, but the iron likewise draws the loadstone, as may be seen by placing a loadstone and a piece of iron on two separate pieces of cork, and making them swim in a basin of water; and if the iron is kept immoveable the loadstone will swim to it, and both are at rest when they come together, which would not be if they did not press equally. On the same principle if a stone fall towards the earth, the quantity of motion both in the earth and the stone is the same; but the space through which the earth moves, in such a case, is too minute to be the subject of observation. For when two bodies attract each other, the space through which the greater approaches the lesser, bears to that through which the lesser approaches the greater, the same proportion as the mass of the lesser bears to the mass of the greater. And this motion, in the case of any body that is observed to fall on the earth would not amount to the 100,000,000,000th part of an inch.—Hence, like-

wise, the reason of rowing with oars—the recoiling of guns—the swimming of fishes in water—the flying of birds through the air, and many other actions—all which are produced on the principle, that action and re-action are always equal.—This and the other laws above stated lie at the foundation of the science of *mechanics* —and they are the laws by which, under the superintendence of the Almighty, the movements of the great system of the universe are directed and supported.

Natural Philosophy has generally been divided into the following branches :—

Mechanics.

This branch, considered in its most extensive range, includes an investigation of the general properties of matter; such as solidity, extension, divisibility, motion, attraction, and repulsion—the laws of gravitation, and of central forces, as they appear to operate in the motions of the celestial bodies; and on the surface of our globe, in the phenomena of falling bodies, the motions of projectiles, the vibrations of pendulums, etc.—the theory of machines, the principles on which their energy depends; the properties of the mechanical powers—the *lever*, the *wheel* and *axle*, the *pulley*, the *inclined plane*, the *wedge*, and the *screw*,—and the effects resulting from their various combinations. From the investigations of philosophers on these subjects, we learn the laws by which the great bodies of the universe are directed in their motions; the laws which bind together the different portions of matter on the surface of the earth, and which regulate the motions of animal, vegetable, and inanimate nature; and the principles on which cranes, mills, wheel-carriages, pile-engines, threshing-machines, locomotive carriages, and other engines, are constructed; by means of which man has been enabled to accomplish operations far beyond the limits of his own physical powers.

Mechanics must be considered as one of the first arts which men would have occasion to practise. It is one of those departments the knowledge and practice of which distinguish civilized man from the untutored and wandering savage. By this science we are

enabled to improve every power and force we find in nature, and to render the knowledge we have acquired of water, air, steam, electricity, and other principles, subservient to the most important purposes of human life and society; and without it little progress could be made in the knowledge of the arrangements and phenomena of nature. By calling to his assistance the aid of mechanical powers, man can raise from the earth weights of immense size, which his own natural strength never could have effected, and can produce such effects, by means of machinery, as would appear to an inexperienced savage the work of enchantment.

The arts depending on mechanical principles must have been known and practised, to a certain extent, in the earliest ages of the world. In the book of Genesis, reference is made by Jacob of ships having then been invented, and in the time of Saul, more than a thousand years before Christ, we learn that the Philistines brought into the field of battle thirty thousand chariots. About eight hundred years before Christ, Uzziah constructed engines on the towers and bulwarks, for the purpose of shooting arrows and great stones. Corn-mills appear to have been an early invention, for they are referred to by Moses in the book of Deuteronomy. From history we learn that Archimedes, two hundreds years before Christ, by his mechanical knowledge and inventions, defended the city of Syracuse, for three successive years, against all the force and power of the Romans. The ancients, in those times, were in the practice of rearing enormous towers 150 feet in height, and 60 in circumference, with a battering ram at the bottom sufficient to beat down walls, with a draw bridge in the middle to be let down upon the wall of the attacked city. On the tops of the pyramids of Egypt are found stones, each of which are as large as a small house, which could never have been raised to such an elevated station without the aid of the most powerful mechanical engines; and throughout Italy, and especially at Rome, are found the ruins of buildings and of monuments, which give us a high idea of the powers and the mechanical genius possessed by the ancient Romans.

The science of Mechanics, being of vast extent, and comprehending a great variety of objects, I cannot propose within the limited space allotted to this work, to give even an outline of its

different subjects; and therefore shall content myself with offering a few miscellaneous remarks or illustrations, chiefly in reference to some of the mechanical powers.

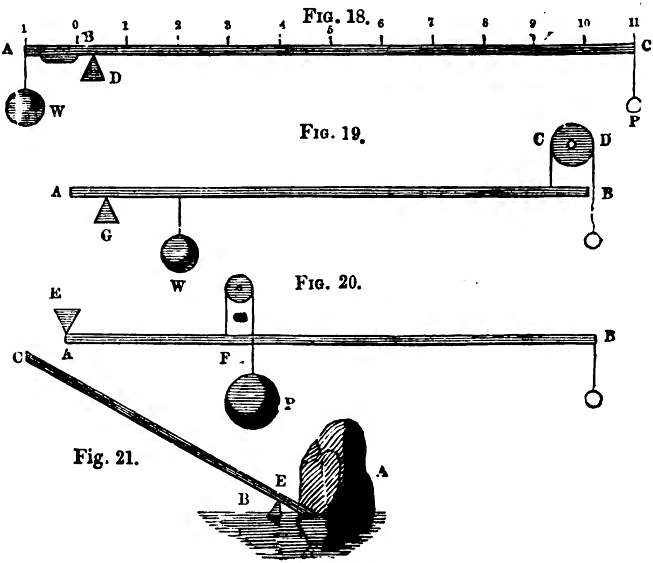
The mechanical powers are simple machines, founded on the principles and laws of motion, by which means we may either cause a small weight overcome a great one, or by means of a great one we may make a small weight move through a space proportionally great. Thus, we may cause a weight of one pound, by moving through the space of ten feet, raise another of ten pounds, through one foot; or by a weight of ten pounds, moving through the space of one foot, we may make a single pound move through the space of ten feet.—The principal moving powers are, 1, the strength of animals, chiefly that of men and horses; 2, the force of steam, one of the most powerful mechanical agents; 3, the force of the wind, as exhibited in the action of windmills; 4, the force of running waters, especially when made to descend a declivity; 5, the force of springs or elastic bodies; and 6, the weight of heavy bodies.

There are generally reckoned *six* mechanical powers, namely the *lever*—the *pulley*—the *wheel and axle*—the *inclined plane*—the *wedge*—and the *screw.*—It is the opinion of many respectable philosophers, that all the mechanical powers may, with propriety, be reduced to two—the *lever*, and the *inclined plane;* for the pulley and the wheel and axle are merely an assemblage of levers. The wedge is evidently composed of two inclined planes, and the screw is only a wedge wrapped round a cylinder.—I shall here confine myself chiefly to a short illustration of the different kinds of levers.

A lever is an inflexible bar of iron or wood, one part of which being supported by a prop, all the other parts turn upon that prop, as their centre of motion. The *arms* of the lever are those parts of the bar which extend on each side of the prop or axis. The axis is called the *fulcrum,* or prop. Levers are generally divided into *three* kinds according to the relative positions of the power, the weight, and fulcrum. In a lever of the *first* kind, as A C, fig. 18, the fulcrum is between the power and weight. In a lever of the *second* kind, as in fig. 19, the weight is between the fulcrum and the power; and in a lever of the *third* kind, as in fig. 20, the power is between the fulcrum and weight.

A lever of the first kind is represented by the bar A B C sup-

ported by the prop D, fig. 18. The parts A B and B C, on different sides of the prop, are called the arms of the lever, the end A of the shorter arm A B being applied to the weight intended to be raised, or to the resistance to be overcome, and the power applied to the end C of the longer arm B C. The principal use of this



LEVERS.

lever is to loosen large stones in the ground, or to raise great weights to small heights, in order to have ropes put under them for raising them higher by other machines.

Thus, if it be required to raise the stone A, fig. 21, which weighs 1000 pounds, by the strength of a man equal to 100 pounds weight, a lever C E, which rests on the prop B, is placed with one end under the stone, and the man presses it down at the other end C. As the man's strength is only equal to the tenth part of the weight of the stone, the arm of the lever from C to the prop B must be ten times as long as from the prop to where it is applied to the stone, in order that the power and weight may balance each other.

In making experiments with this lever, the shorter arm A B, fig. 18, must be made as much thicker than the longer arm B C as will be sufficient to balance it on the prop D. This supposed, let P represent a power whose gravity is equal to one ounce, and W a weight whose gravity is equal to eleven ounces. Now, if the power be eleven times as far from the prop as the weight is, they will exactly counterpoise, and a small addition to the power P will cause it to descend, and raise the weight W, and the velocity with which the power descends will be to the velocity with which the weight rises, as eleven to one; that is directly as their distances from the prop, and consequently as the spaces through which they move. Hence, it is plain that a man who, by his natural strength, without the help of any machine, could support an hundred weight, will by the help of this lever be enabled to support eleven hundred. If the weight be less or the power greater, the prop may be placed so much farther from the weight, and then it can be raised to a proportionably greater height.

To this kind of lever may be reduced such instruments as the following, scissors, pincers, snuffers, etc., which are made of two levers acting contrary to each other, their prop or centre of motion being the pin which keeps them together. A poker in the act of stirring a fire is a lever of this kind: the bar of the grate on which it rests is the fulcrum, the coals the weight to be overcome, and the hand is the power. A crow bar applied to elevate a stone or other weight is likewise a lever of this kind. The fulcrum is another stone placed near that which is to be raised, and the power is the hand placed at the other end of the bar. A handspike is a similar example. The brake of a pump is also a lever of this kind, the pump rods and piston being the weight to be raised.

The *second kind of lever* is when the fulcrum is at one end, the power at the other, and the weight between them. In fig 19, G is the fulcrum, W the weight, and P the power. In this as well as in the former, the advantage gained is as the distance of the power from the prop, to the distance of the weight from the prop. Thus if A B be a lever on which the weight W of six ounces hangs at the distance of one inch from the prop G, and a power P equal to the weight of one ounce hangs at the end B, six inches from the prop; by the cord C D going over the fixed pulley E, the power will just support the weight; and a small addition to the power will raise the weight one inch for every six inches that the power

descends. This lever shows the reason why two men carrying a burden upon a stick betwen them bear unequal shares of the burden in the inverse proportion of their distances from it. For the nearer either of them is to the burden, the greater share he bears of it, and if he goes directly under it he bears the whole. Thus, if one man be at G, and the other at B, having the pole or stick A B resting on their shoulders; if the burden or weight W be placed five times as near the man at G, as it is to the man at B, the former will bear five times as much weight as the latter. This is likewise applicable to the case of two horses of unequal strength, where the beam may be so divided that the horses shall draw up in proportion to their respective ability.

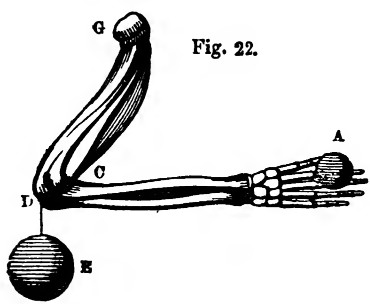
An oar is a lever of this kind. The reaction of the water against the blade is the fulcrum; the boat is the weight, and the hand of the boatman the power. The rudder of a ship or boat is an example of the same kind of lever, and may be explained in the same way. A chipping knife is likewise an example of this kind of lever. The end attached to the bench is the fulcrum, and the weight the resistance of the substance to be cut placed beneath it. A door moved with hinges is another example. Nut crackers are two levers of this kind; the hinge which unites them being the fulcrum, the resistance of the shell placed between them being the weight, and the hand applied to the extremity being the power. A wheelbarrow is a lever of this kind; the fulcrum being the point at which the wheel presses on the ground, and the weight being that of the barrow and its load, collected at their centre of gravity.

A lever of *the third kind* is when the prop is at one end, the weight at the other, and the power applied between them. Here the power must exceed the weight in the same proportion as the distance of the weight from the prop exceeds the distance of the power. Thus, let E, fig. 20, be the prop, and W a weight of one pound, placed three times as far from the prop as the power P acts at F, by the cord C going over the pulley D; in this case the power must be equal to three pounds, in order to support the weight of one pound. In this instrument, therefore, the power acts upon the weight to a mechanical disadvantage, inasmuch as a greater power is necessary to support or move the weight than would be required if the power were immediately applied to the weight without the intervention of a machine. It may be shown,

howover, that in cases where this power is applied, the advantage which is lost in force is gained in despatch; and that in proportion as the weight is less than the power which moves it, so will the speed of its motion be greater than that of the power. Hence, a lever of this kind is only used in cases where the exertion of great power is a consideration *subordinate* to those of rapidity and despatch.

The most striking example of levers of this kind is found in the animal economy. The limbs of animals are generally levers of this description. The socket of the bone is the fulcrum; a strong muscle attached to the bone near the socket is the power, and the weight of the limb, together with whatever resistance is opposed to its motion, is the weight. In this case, a slight contraction of the muscle gives a considerable motion to the limb. Let us take the arm, as an example. In fig. 22, D is the elbow, and the centre of motion, the power is the motion produced by the muscle at C—about one tenth part as far below the elbow as the hand is—and A is the weight to be raised. The muscle must accordingly exert

Fig. 22.



AN ARM.

a power equal to one hundred pounds to raise a weight of ten pounds, or ten times the weight to be raised. But the muscles are endowed with an extraordinary degree of force. Borelli has calculated that the immediate force of the *biceps* or double headed muscle, which bends the arm in an ordinary man, is equal to about 300 pounds, while that of the muscles which raise the lower jaw

is much greater. He has also demonstrated that when a weight E, weighing fifty-five pounds, is held up in equilibrio by the elbow D, of the arm G D—when stretched out parallel to the ground—the muscle named *deltoides*, which raises the arm in this position, exerts a force of 60,000 pounds. We have many instances of the extraordinary force of the muscles as displayed in the feats of several individuals. Dr. Desaguliers mentions one Topham, a carpenter, who could readily lift about 800 pounds. He rolled up a stronger pewter dish with his fingers, and bent a poker, three inches in circumference, to a right angle, by striking it upon his arm, whilst he bent and unbent another about his neck. He also supported and raised two brewer's butts, containing beer, with comparative ease.

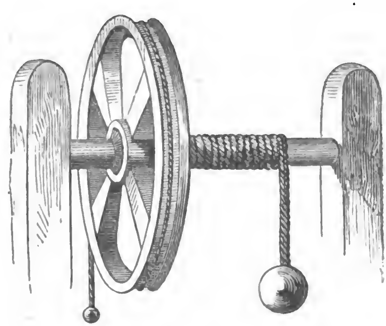
The treddle of a turning lathe may also be considered as a lever of this kind. The hinge which attaches it to the floor is the fulcrum, the foot applied to it near the hinge is the power, and the crank upon the axis of the fly-wheel with which its extremity is connected is the weight. Tongs are levers of this kind, and so are the shears used in shearing sheep. In both these cases, the power is the hand placed immediately below the fulcrum or point where the two levers are connected.—A ladder which is to be raised by the strength of a man's arms represents a lever of this kind, where the fulcrum is that end which is fixed against the wall; the weight may be considered as at the top part of the ladder, and the power is the strength applied to the rearing of it.—The wheels in clock and watch work may be reckoned levers of this kind, because the power that moves them acts near the *centre* of motion by a pinion, and the resistance it has to overcome against the teeth at the *circumference*.

A *Hammer Lever* differs only in its form from a lever of the first kind. The name is derived from its use, that of drawing a nail out of wood by a hammer. Suppose the shaft of a hammer to be five times as long as the iron part that draws the nail, the lower part resting on the board, as a fulcrum, then by pulling backwards the end of the shaft, a man will draw a nail with one *fifth* part of the power he must use to pull it out with a pair of pincers; in which case the nail would move as fast as the hand; but with the hammer the hand moves five times as much as the nail, by the time the nail is drawn out.

Such is a brief illustration of the different kinds of levers used

in mechanical operations. It would be inconsistent with the limited plan of this work to attempt any particular illustration of the other mechanical powers, and therefore I shall do little more than give a brief definition of them.

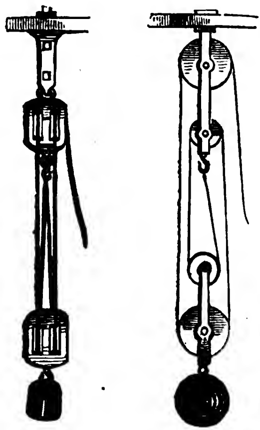
THE WHEEL AND AXLE.—This is a mechanical power which is much used, and is made in a variety of forms. It consists of a wheel fixed to an axle or cylinder, so that both turn round together. Sometimes it is merely a cylinder with projecting spokes, in which case the power is applied at the circumference of the wheel, and the weight to be raised is fastened to a rope which coils round the axle or cylinder. The advantage gained in this case is in proportion as the circumference of the wheel is greater than that of the axis; or as the diameter of the wheel is greater than the diameter of the axis. If the diameter of the wheel be four feet, and the diameter of the axis be only eight inches, then a power of 100 pounds or the strength of a man applied to the spokes, equal to 100 pounds, will balance a weight of 600 pounds. In this case, as in the lever, the power will travel over six times as much space as the weight, when the machine is put in motion. Again, suppose a water wheel to be twelve feet diameter and the axle one foot, the power acting at the circumference of the large wheel moves over twelve times the space which the circumference of the axle moves; hence twelve *cwts.* may be raised with the power of one *cwt.* The wheel and axle may be considered as a perpendicular *lever*, the centre of the axis being the fulcrum, and the long and the short arms, the diameter of the wheel and the diameter of the axis. To this mechanical power may be referred all windlasses, cranes, mills, capstans, wind mills, and water mills, which are framed on the principle of the wheel and axle.



WHEEL AND AXLE.

THE PULLEY.—This consists of a small wheel turning on an axis

with a rope passing over it. The small wheel is called a *sheeve*, and is so fixed to a box or block as to be moveable round a pin passing through its centre. Pulleys are either *fixed* or *moveable*. The fixed pulley gives no mechanical advantage, but is used only to change the direction of the power. By means of it a man may raise a weight to any height without moving from the place in which he is. The *moveable pulley* is fixed to the weight and rises and falls with it; it doubles the power, and the advantage gained by it is two to one. A man may therefore raise twice as much by it as by his strength alone; and by encreasing the number of such pulleys, the force may be encreased in any ratio whatever. If four pulleys, for example, be connected by means of as many different cords, and a force of one pound exerted, the *first* will give two pounds, the *second* four pounds, and the *third* eight pounds. In general, the advantage gained by pulleys is found by multiplying the number of pulleys in the lower block by two.



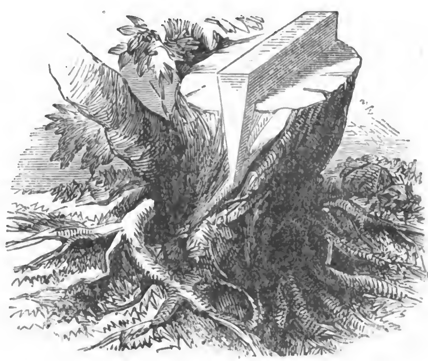
A PULLEY.

THE INCLINED PLANE. — This is merely a plane surface inclined to the horizon, and is of use for moving weights from one level to another, as for example, for rolling up heavy bodies, as casks, wheelbarrows when loaded, etc. In this case, the power necessary for raising a weight will depend on the proportion

THE INCLINED PLANE.

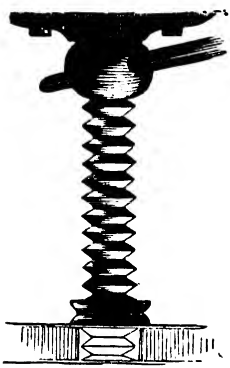
that the length of the plane bears to the perpendicular lift. Thus, if we suppose the perpendicular height one third of the length, it will be found that a force equal to one pound will raise a weight of three times that amount, though it must of necessity pass through three times the distance that the body is raised. If the plane be twenty feet long, and the perpendicular height four feet, then 500 pounds would be balanced upon it by 100 pounds, because the plane is five times the length of the perpendicular height. It is probable that this simple machine was employed by the Druids in the construction of that stupendous monument, *Stonehenge.* To the inclined plane may be reduced hatchets, chizels, and other edged tools which are sloped only on one side.

THE WEDGE.—The wedge may be considered as two equally inclined planes united at their bases. The advantage gained by this mechanical power is in proportion as the length of the two sides of the wedge is greater than the breadth of the back. This is a mechanical power of considerable importance in mining, felling of trees, and raising large weights; for by its means vessels of war weighing many thousand tons are lifted from their supports by the strength of a few men applied to a battering ram. Its chief use, however, is in penetrating and dividing bodies, since not only wood but even rocks can be split by it. It is also used, as well as the screw, to unite the parts of machines; pins, bolts, and nails being wedges retained in their places by friction.—All cutting instruments used in the common purposes of life, and some sorts of chizels chamfered on both sides, may be referred to the principle of the wedge.



THE WEDGE.

THE SCREW is the last mechanical power that remains to be noticed. It is nothing more than an inclined plane used with a lever or winch to assist in turning it. It is in fact nothing more than an inclined plane coiled round a cylinder. The screw may be conceived to be made by cutting a piece of paper into the form of an inclined plane, and then wrapping it round a cylinder; the edge of the paper will form a spiral round the cylinder which will answer to the thread of the screw. The advantage gained by this mechanical power is in proportion as the circumference of the circle made by the lever or winch is greater than the interval between the threads of the screw. Thus, supposing the distance of the spirals to be half an inch, and the length of the winch twelve inches, the circle described by the handle of the winch, when the power acts, will be seventy-six inches nearly, or about 152 half inches, and consequently 152 times as great as the distance between the spirals; and therefore a power at the handle whose intensity is equal to no more than a single pound will balance 152 pounds acting against the screw, and as much additional force as is equal to overcome the friction will raise 152 pounds, and the velocity of the power will be to the velocity of the weight as 152 to 1. Hence it appears that the longer the winch is, and the nearer the spirals are to each other, so much the greater is the force of the screw.—Almost all kinds of presses, common work screws, etc., act upon the principle of this mechanical power.



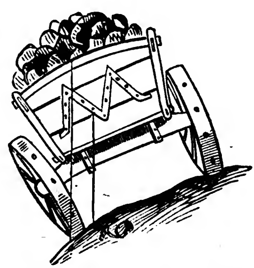
THE SCREW.

Omitting the other topics connected with *Mechanics*, I shall just offer a few illustrations of the CENTRE OF GRAVITY.

The *centre of gravity* of a body is that point about which all its parts do in any situation exactly balance each other, so that if a body be suspended by the centre of gravity, it will rest in any position. If a line be drawn from the centre of gravity of a body perpendicular to the horizon, it is called *the line of direction*, because it is the line that the centre of gravity would describe if the body fell freely. It is the property of this line that while it

falls *within* the base upon which the body stands, the body cannot fall; but if it fall *without* the base, the body will be overturned. The broader the base, and the nearer the line of direction is to the centre of it, the more firmly does a body stand, and the narrower the base of a body, and the nearer the line of direction is to the side of it, the more easily will it be overthrown.

A careful attention to these principles is of considerable importance in various operations in human life, and in guarding us from various dangers. From such considerations we may learn the principle on which the stability of loaded carriages depends. When the load is placed at a considerable elevation above the wheels, the centre of gravity is elevated, and the carriage becomes proportionally insecure. In coaches for the conveyance of passengers, the luggage is therefore sometimes placed below the body of the coach; but light parcels of large bulk may be placed on the top with impunity. When the centre of gravity of a carriage is much elevated, there is considerable danger of its being overthrown, if a corner be turned sharply and with a rapid pace; for the centrifugal force then acting on the centre of gravity will easily raise it through the small height which is necessary to turn the carriage over the external wheels.—The same waggon will have greater stability when loaded with a heavy substance which occupies a small space, such as metal, than when it carries the same weight of lighter substances, such as hay; because the centre of gravity in the latter case will be much more elevated.—From the same principle we learn how absurd it is for people to rise hastily in a coach when it is in danger of being overturned; for by this means they raise the centre of gravity so far as to endanger throwing it quite out of the vehicle; if this be done it will be overset; whereas, by keeping as close to the bottom as possible they would bring the line of direction farther within the base, and prevent the carriage from being overturned.



A WAGGON ON THE VERGE OF OVERTURNING.

By a sort of necessity or instinct, all animals adapt their postures and motions to the position of the centre of gravity of their

bodies. With respect to the human body it is observable, that whether a man be fat or lean, the centre of gravity is always near the same place—in the pelvis, between the hips, the ossa pubis, and the lower parts of the back bone. Raising up the arms or legs will raise up the centre of gravity a little; but still it is so placed that the limbs move freely round it; the centre of gravity at the same time moving much less than if it was in any other part of the body. When a man *stands*, the line of direction of his weight must fall within the base formed by his feet. It is evident that the more his toes are turned outwards the more contracted the base will be, and the more liable he will be to fall backwards or forwards. Also the closer his feet are together, the more contracted the base will be, and the more liable he will be to fall to either side. When a man *walks*, the legs are alternately lifted from the ground, and the centre of gravity is either unsupported or thrown from the one side to the other. The body is also thrown a little forward in order that the tendency of the centre of gravity to fall in the direction of the toes may assist the muscular action in propelling the body.—When a porter carries a load, his position must be supported by the centre of gravity of his body and the load taken together. If he bore the load perpendicularly on his back, the line of direction would pass beyond his heels, and he would fall backwards. To bring the centre of gravity over his feet, he accordingly leans forward. If a nurse carry a child she leans *back* for a like reason. A person sitting in a chair which has no back cannot rise from it without either stooping forward to bring the centre of gravity over his feet, or drawing back the feet to bring them under the centre of gravity.

In like manner animals are taught by instinct to preserve the centre of gravity of their bodies, so that it shall be properly supported. A quadruped,—a horse for example—never raises both feet on the same side, simultaneously; for in this case the centre of gravity would remain unsupported. When a horse *stands*, the line of gravity must fall within the quadrilateral space made by his four feet. When he *walks*, he has always three feet on the ground, and one up. When a horse *trots*, he takes up two feet together, and sets down two together, diagonally opposite. When he *gallops*, he takes up his feet one by one, and sets them down one by one. Some animals, however, strike with the two fore feet nearly at once, and the two hind feet nearly at once, and

consequently have not above two feet on the ground at once. The walking of birds is not unlike that of men, only their weight is supported by the strength of muscles, since their joints are always bent.

It is by knowing exactly how to keep the common centre of gravity that rope-dancers are able to perform their feats. The evolutions of the performer are found to be facilitated by holding in his hand a heavy pole. His security in this case depends not on the centre of gravity of his body, but on that of his body and the pole taken together. This point is near the centre of the pole, so that, in fact, he may be said to hold in his hands the point on the position of which the faculty of his feats depends.

Without a knowledge of the laws of motion, and assistance from the combined effects of the mechanical powers, man would be a very limited being, his enjoyments would be few, and his active energies confined within a very narrow range. In a savage state, ignorant of manufactures, agriculture, architecture, navigation, and the other arts which depend upon mechanical combinations, he is exposed, without shelter, to the inclemencies of the season; he is unable to transport himself beyond seas and oceans, to visit other climes, and other tribes of his fellow-men; he exists in the desert, comfortless and unimproved; the fertile soil, over which he roams, is covered with thorns and briers and thickets, for the haunt of beasts of prey; his enjoyments are little superior to those of the lion, the hyæna, and the elephant, while he is much their inferior in point of agility and physical strength. But, when philosophy has once demonstrated the principles of Mechanics, and introduced the practice of the useful Arts, "the wilderness and the solitary place are made glad, and the desert rejoices and blossoms as the rose." Cities are founded, and gradually rise to opulence and splendour; palaces and temples are reared; the damp cavern, and the rush-built hut, are exchanged for the warm and comfortable apartments of a substantial mansion; ships are built, and navigated across the ocean; the treasures of one country are conveyed to another; an intercourse is carried on between the most distant tribes of mankind; commerce flourishes, and machinery of all kinds is erected for facilitating human labour, and promoting the enjoyments of man. And, when the principles and the practice of "pure and undefiled religion" accompany these physical and mechanical operations, love and affection diffuse their

benign influence; the prospect brightens as years roll on, and man advances with pleasure and improvement, to the scene of his high destination.

Hydrostatics.

Hydrostatics treats of *the pressure and equilibrium of fluids.* From the experiments which have been made in this branch of philosophy, the following important principles, among many others, have been deduced:—

(1.) *That the surface of all waters which have a communication whilst they are at rest, will be perfectly level.*—This principle will be more clearly understood by an inspection of the following figures. If water be poured into the tube A, (Fig. 23,) it will run through the horizontal tube E, and rise in the opposite tube B, to the same height at which it stands at A. It is on this principle that water is now conveyed under ground, through conduit pipes, and made to rise to the level of the fountain whence it is drawn. The city of Edinburgh, a considerable part of which is elevated above the level of the surrounding country, is supplied with water from a resorvoir on the Pentland hills, several miles distant. The water is conveyed in leaden pipes down the declivity of the hill, along the interjacent plain, and up to the entrance of the castle, whence it is distributed to all parts of the city. If the point A represent the level of the reservoir, C D will represent the plane along which the water is conveyed, and B the elevation to which it rises on the Castle-hill. On the same principle, and in a similar manner, the city of London is supplied with water. Had the ancients been acquainted with this simple but important principle, it would have saved them the labour and expense of rearing those stupendous works of art, the *Aqueducts*, which consisted of numerous arches of a vast size, and sometimes piled one above another.

FIG. 23.

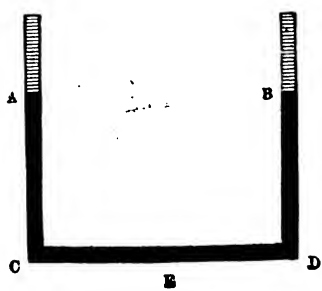
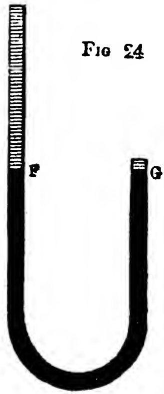


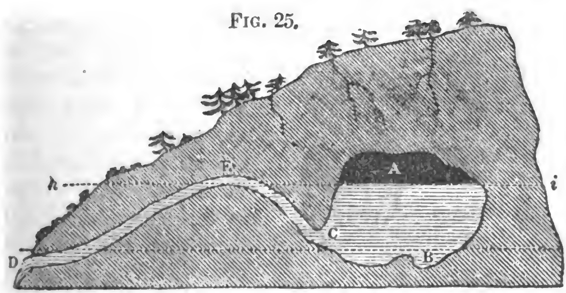
Fig. 24 represents the *syphon*, the action of which depends upon the pressure of the atmosphere. If this instrument be filled with water, or any other liquid, and the shorter leg G plunged to the bottom of a cask, or other vessel containing the same liquid, the water will run out at the longer leg F till the vessel be emptied, in consequence of the atmospheric pressure upon the surface of the liquid. On this principle water may be conveyed over a rising ground to any distance, provided the perpendicular height of the syphon above the surface of the water in the fountain does not exceed thirty-two or thirty-three feet. On the same principle are constructed the *fountain at command*, the *cup of Tantalus*, and other entertaining devices. The same principle, too, enables us to account for springs which are sometimes found on the tops of mountains, and for the phenomena of *intermitting* springs, or those which flow and stop by regular alternations.

Fig 24



The following figure will explain the nature of intermitting springs. Suppose A B a cavity or receptacle of water formed in the bowels of a hill where the spring is situated, which gradually fills with water like other reservoirs, and that, by the interposition of some stratum of rock or other substance, the tube C D—which conveys the water to the spring or mouth where it issues—is bent

Fig. 25.



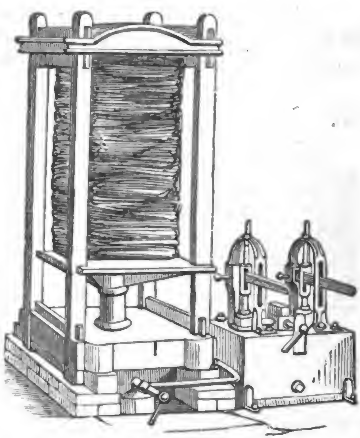
SECTION OF A MOUNTAIN.

in the form of a syphon. Whenever the reservoir A B is filled as high as the bend of the tube, or to the level of *h i*, the water will rise in the tube, and begin to flow into the spring, which will con-

tinue till the reservoir be exhausted. While this process is going on the water in the spring will rise, and as soon as the reservoir is exhausted, the water will appear to fall in the well of the spring, and will continue to fall till the reservoir is again supplied to the height of the syphon, when the process of filling will be again renewed. It is obvious that unless the water in the reservoir rises above the height of the bend of the Syphon E, the well cannot be filled.

(2.) *Any quantity of fluid, however small, may be made to counterpoise any quantity, however large.* This is what has generally been termed the Hydrostatical Paradox; and from this principle it follows, that a quantity of water may exert a force several hundred times greater or less, according to the manner in which it is employed. This force depends on the height of the column of water, independent of its quantity; for its pressure depends on its perpendicular height. By means of water conveyed through a very small perpendicular tube, of great length, a very strong hogshead has been burst to pieces, and the water scattered about with incredible force. On this principle, the *hydrostatic press,* and other engines of immense power, have been constructed.

By the application of this power, Mr. Bramah formed the Hydrostatic press, by which a *prodigious force* is obtained. By means of this instrument, hay, straw, wool, silks, cottons, and other light substances, may be pressed into a very small bulk, so as to be taken in large quantities on board a ship. And therefore this hydrostatical and mechanical power is now in extensive use by various classes of artists and manufacturers. With a machine of this description, of little more than the size of a teapot—standing before him on a table—a man is enabled to cut through a thick bar of iron, as easily as he could clip a piece of paste-board with a pair of large shears; and a pressure of five or six hundred



HYDROSTATIC PRESS.

tons may be brought to bear on any substances which we wish to press, to tear up, to cut to pieces, or to pull asunder. By means of a powerful hydraulic press the tubes of the Britannia railway bridge which unites the isle of Anglesea with the main land, were raised into their present position. From the principle now stated we may learn what mischief may sometimes be done by a very small quantity of water, when it happens at any time to act according to its perpendicular height. If in any building, near the foundation, a small quantity of water not more than the extent of a square yard, has settled, and completely filled up the whole vacant space—if a tube of twenty-eight or thirty feet long were thrust down into the water, and filled with water from above, a force of more than five or six tons would be applied to that part of the building, which would blow it up with the force of gunpowder. Hence, it has sometimes happened, that the walls of a house have been undermined and destroyed, by rain falling into long narrow chinks, which had inadvertently been left, when the walls were built. And hence, by similar processes in nature, connected with pools of water in the bowels of the earth, the most dreadful devastations have sometimes happened, and mountains been shaken and convulsed to their centre. And hence we may learn the utility of being acquainted with the principles of natural science, and the powers and operations of nature.

(3.) Fluids press not only perpendicularly, in common with solids, *but they also press upwards, sideways, and in every direction equally.* This may be illustrated as follows:—Take a glass tube open at both ends, and stopping one end with a cork, immerse the other in water. The water will be prevented from rising far in the tube by the air it contains; but if the cork is taken out, the air in the tube will be suffered to escape, and the water will rise to a level with the surrounding water: which proves the pressure *upwards.* The same effect will take place, if the tube be inclined in any direction, or if we use a tube which is bent in any direction. —Again, if we bore a hole in the side of a tube or of any vessel full of water, the fluid will spout out, which shows that fluids press *laterally* as well as in other directions.—The perpendicular pressure of fluids may be further illustrated by the following experiments:— If a bladder full of air be immersed in water, the perpendicular pressure is manifest from the circumstance, that the deeper the

bladder is immersed the more will its bulk be contracted.—An empty bottle being corked, and, by means of a weight, let down to a certain depth into the sea, will either be broken, or the cork will be driven into it by the perpendicular pressure. But a bottle filled with water, wine, or other liquids, may be let down to any depth, without damage, because in this case the internal pressure is equal to the external.

The pressure of fluids *upwards* is shown by an instrument known by the name of the *Hydrostatic Bellows.* This instrument consists of two oval boards, about eighteen inches long and sixteen inches broad, covered with leather, to rise and fall like the common bellows, but without valves. A pipe three feet long is fixed at the top board, having an opening into the interior. If, then, a little water be made to run into the bellows to separate the boards — weights to the amount of two or three hundred pounds may be placed on the upper board; after which, when the pipe is supplied with water, the water will, by its upper pressure, lift up and sustain the weights.—On the principle of this upper pressure, lead and other heavy substances may be made to swim in water, as in the following experiment. Plunge a glass tube, open throughout, into a vessel of water: Hold, by a string, a flat piece of lead fast to the bottom of the tube to prevent the water from getting in between the lead and the glass; and supposing the circular piece of lead to be one-half inch in thickness, if the tube is immersed in the vessel of water to about six inches deep and the string let go, the lead will not fall, but will be kept supported by the upward pressure of the water from below. Lead is about eleven times heavier than water, and the six inches of water is more than eleven times the thickness of the lead, and consequently supports it; but if the tube were immersed only four or five inches in the water,

HYDROSTATIC BELLOWS.

the lead would sink. In this experiment, the lead should be exactly the width of the tube; the lower end of the tube and the upper surface of the lead should be both ground truly flat, and to the upper surface of the lead, a piece of leather, soft and well soaked, should be nicely adapted, to prevent the water from oozing between the lead and the tube. If the experiment were made with gold, the depth to which it would have to be plunged would be nearly ten inches, because gold is about nineteen times heavier than water.

(4.) *A fluid specifically heavier than another will float upon its surface.* For the lighter fluid will be less powerfully acted upon by the force of gravitation than the fluid which is heavier; and, of course, the heavier will occupy the lowest place. The following experiments will illustrate this principle. Take a small and open vessel of wine, and place it within a large vessel of water, the vessel which contains the wine will ascend towards the surface, being the lighter body. If water be poured into a phial, or a tube closed at one end, and oil of turpentine or any other oil be poured in above it, the oil will continue upon the top without mingling with the water. If mercury, water, wine, oil, alcohol, spirit of turpentine, be placed into a phial, in the order of their specific gravities, they will remain quite separate without commingling with each other.—When a solid body floats on the surface of a fluid specifically heavier than itself, it will sink into the fluid till it has displaced a portion of the fluid equal in weight to the whole solid. This may be illustrated as follows:—Take a cube of wood and place it on the top of a small jar *exactly filled* with water. A part of the cube will be immersed and will displace a portion of the water, which will run over the mouth of the jar. Next, take the cube out of the water and put it into a scale with which an empty vessel in the other scale stands balanced. Then pour water into that vessel till the equilibrium is restored, and that portion of water will exactly fill up the jar in which the cube of wood was placed;—which shows that the weight of the water displaced is exactly equal to the weight of the wood. In the process of Stereotyping, this principle is simply illustrated by the iron false bottom of the plunger floating in the mass of molten lead used for casting, the lead being the lighter metal.

(5.) The relative weights which equal bulks of different bodies

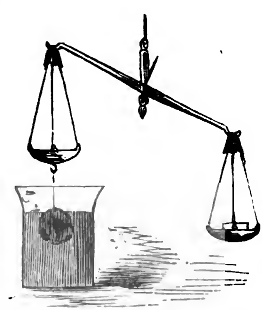
have to each other is called their *specific gravities.* And as it is usual to compare them with that of water, and as it is by weighing bodies in water that their specific gravities are found, we may here offer a few remarks on this point, as connected with hydrostatics. That the reader may understand what is meant by specific gravities, we may state, that a cubic foot of cork, for example, is not of equal weight with a cubic foot of water, but the water is four times heavier than the cork, so that a cubic foot of water would weigh as much as four of cork. The specific gravity of *lead ore* is double that of *diamond,* because one cubic inch of lead is twice as heavy, or contains as much matter as one cubic inch of diamond.

The art of finding the specific gravities of bodies is generally understood to have been invented by ARCHIMEDES, the celebrated mechanist and mathematician of Syracuse, who flourished about 200 years before Christ. The story goes, that a goldsmith having been employed by Hiero, king of Syracuse, to make a crown, a mass of gold was given him for that purpose. But it was suspected that the workman had kept back part of the gold for his own use, and made up the weight by alloying the crown with copper. Hiero, not knowing how to ascertain the truth in relation to this circumstance, referred the matter to Archimedes. The philosopher, after having long studied the subject in vain, at last accidentally hit upon a method of verifying the king's suspicion. Going one day into a bath, he observed that the water rose higher in the tub or bath than it was before, and immediately began to reflect that any body of an equal *bulk* with himself would have raised the water just to the same height, though a body of equal *weight,* but not of equal bulk would not raise it so much. This idea suggested to him the mode of finding out what he so much desired to ascertain; and, in the transports of his joy on making such a discovery, he rushed out of the bath, and ran naked through the streets of Syracuse, exclaiming in the Greek language "Eureka! Eureka!" "I have found it! I have found it!"

Now, since gold was the heaviest of all metals known to Archimedes, it appeared evident that it must be of less bulk, according to its weight, than any other metal. He procured a mass of pure gold equally heavy with the crown when weighed in air, and desired that it should be weighed against the crown in water, and if the crown was not alloyed, it would counterbalance the mass

of gold when they were both immersed in water, as well as it did when they were immersed in air. But, on making the trial, he found that the mass of gold weighed much heavier in water than did the crown: not only so, but when the mass and crown were immersed separately in one vessel of water, the crown raised the water much higher than the mass of gold did; which proved that it was alloyed with some lighter metal which encreased its bulk. By making, in this manner, trials of different metals, equally heavy as the crown, he found out the quantity of alloy which had been introduced into it.

A body immersed in a fluid will sink to the bottom of it if it be heavier than its bulk of the fluid; and if it be suspended in it, it will lose as much of what it weighed in air as its bulk of the fluid weighs. Hence all bodies of equal bulks, which would sink in fluids, lose equal weights when suspended in them; and unequal bodies lose in proportion to their bulks. This is the foundation of the whole doctrine of specific gravities.—The specific gravities of all bodies that sink in water may be found first by weighing the body in air and then in water, and dividing the weight in air by the loss of weight in water. For example, a guinea weighs one hundred and twenty-nine grains in air, and when weighed in water it loses seven and one quarter grains, which shows that a quantity of water of equal bulk with the guinea weighs seven and one quarter grains. Divide one hundred and twenty-nine by seven and one quarter, the quotient will be 17.793, or a little more than seventeen and three quarters, which proves the guinea to be seventeen and three quarter times heavier than its bulk of water. The instrument used to find the specific gravities of bodies is called the *Hydrostatic Balance*, which differs but little from a common balance, only it has a hook at the bottom of one of the scales on which different substances that are to be examined may be hung by horse hairs, or silk threads, so as to be immersed in a vessel of water without wetting the scale.



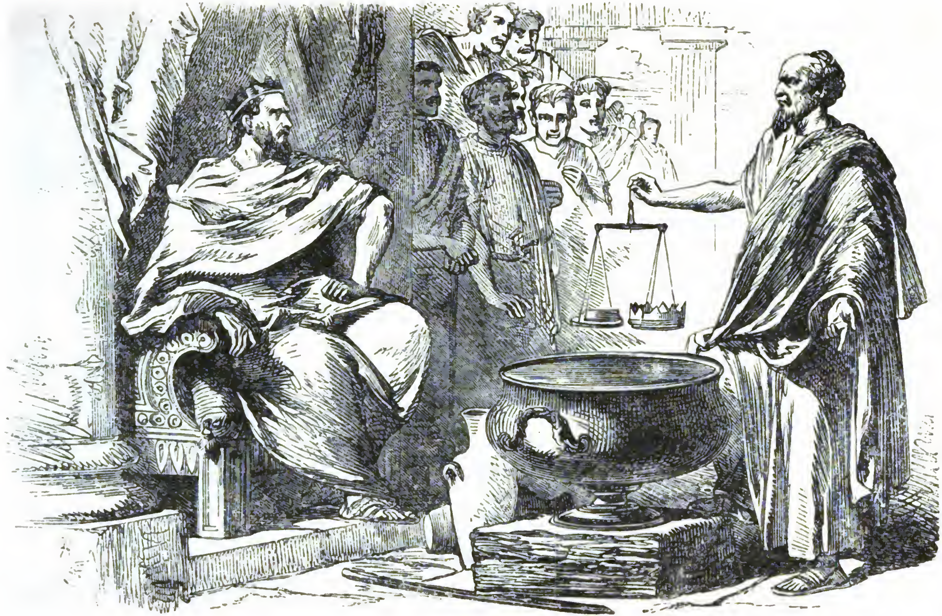
HYDROSTATIC BALANCE.

The following is a list of the specific gravities of a few common substances, that of distilled water being the standard:—

Distilled water, ...	1·000	Glass, white flint, ...	3·300
Sea water, ...	1·026	" crown, ...	2·520
Platina, drawn into wire,	21·042	" common plate, ...	2·760
Pure gold, ...	19·258	" bottle, ...	2·732
Standard gold, ...	17·486	Ivory, ...	1·825
Lead, fused, ...	11·352	Sulphur, ...	1·990
Mercury, ...	13·568	Phosphorus, ...	1.714
Silver, ...	10·474	Ebony, ...	1·117
Bismuth, ...	9·823	Yellow amber, ...	1·078
Nickel, ...	8·660	Concentrated sulphuric acid,	2·125
Brass, in wire, ...	8·544	Coal, ...	1·250
" cast, ...	8·396	Chalk, ...	1·793
Copper, drawn into wire,	8·878	Milk, ...	1·034
" fused, ...	7·788	Mahogany, ...	1·063
Tin, ...	7·291	Boxwood, ...	1·030
Iron, cast, ...	7·207	Oil, ...	·920
" bar, ...	7·788	Ice, ...	·908
Steel, ...	7·840	Brandy, ...	·920
Zinc, ...	7·191	Living men, ...	·891
Copper, native, ...	7·800	Ash, ...	·800
Copper ore, Cornish, ...	5·452	Beech, ...	·700
Manganese, ...	6·850	Elm, ...	·600
Tellurium, ...	6·115	Fir, ...	·550
Magnesia, ...	2·600	Cork, ...	·240
Lime, ...	2·300	Tallow, ...	·942
Talc, German, ...	2·246	Yellow wax, ...	·965
Diamond, ...	3·521	Common air,... ...	·00112
Rock crystal,... ...	2·650	Hydrogen gas, ...	·000105

The above table shows the specific gravities of the various substances here stated; and when the specific gravity of any body is known, it is easy to calculate the *weight* of any given bulk of that body, by multiplying the number opposite to it by 1000—the weight of a cubic foot of water in ounces avoirdupois. Thus, the weight of a cubic foot of mercury is 13,568 ounces avoirdupois, or 848 pounds; the weight of a cubic foot of lead is 11,352 ounces, or 709 and a half pounds, etc.

A body specifically lighter than a fluid will swim upon its surface, in such a manner that a quantity of the fluid equal in bulk with the immersed part of the body will be as heavy as the whole body. Hence, the lighter a fluid is the deeper will a body sink in it.

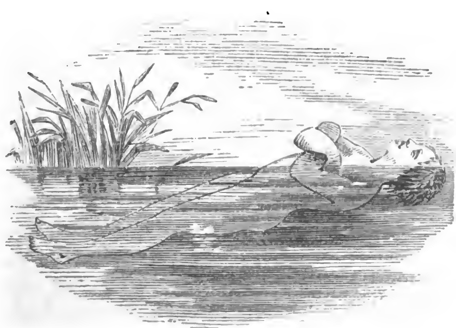


ARCHIMEDES' APPLICATION OF HYDROSTATICS.

On this principle the weight of a ship or any other body that floats in water may be found. For if we multiply the number of cubic feet which are under the surface by 62·5 = the number of pounds in one cubic foot of fresh water; or by 64·4 = the number of pounds in a cubic foot of salt water, the product will be the weight of the ship and all that is in it. For since it is the weight of the ship that displaces the water, it must continue to sink till it has removed as much water as is equal to it in weight, and therefore the part immersed must be equal in bulk to such a portion of the water as is equal to the weight of the whole ship.

Various experiments have been made in order to determine the specific gravity of living men, and from trials which were made on ten different persons by Mr. Robertson, librarian to the Royal Society, it appeared that their specific gravity, as expressed in the table, was 0·891, or about one-ninth less than common water. In some cases, however, they are undoubtedly heavier, otherwise they would not so easily sink to the bottom, when by accident they happen to fall into a river or into the sea. It has been calculated, in regard to any middle-sized man whose absolute weight is 135 pounds, that four pounds of cork connected with his body will keep such a person from sinking, so that he may remain with his head completely above water.

Admitting that the bodies of all persons were specifically lighter



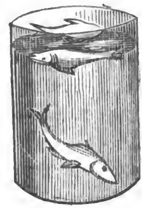
FLOATING.

than water, yet there are certain circumstances which prevent them from swimming when plunged in the water. It requires a certain degree of skill for a person to throw himself into such a position in the water as will cause him to float like a piece of wood. Dr. Franklin recommends a person to throw himself in a slanting position on his back, but that his whole body except the face should be kept under water. Unskilful persons, in the act of attempting this, are apt to plunge about and struggle; by this means they take water in at their mouths and nostrils, which of itself would soon make them as heavy or even heavier than the water. The coldness of the water likewise tends to contract the body, and render it specifically heavier than water; perhaps fear has the same tendency; all which circumstances will account for a person sinking in the water. Man appears more helpless when plunged in this element than other land animals. The brute creation seem to swim naturally; but the human race must acquire the art by practice. In other animals the trunk of the body is large and their extremities small. In man the arms and legs are small in proportion to the bulk of the body, but the specific gravity of the extremities is greater than that of the trunk; consequently it will be more difficult for man than four-footed animals to keep above the water. Besides, the act of swimming seems more natural to them than to us, as it corresponds more nearly to their mode of running and walking than to ours.

As salt water, or the water of the sea, is specifically heavier than fresh or river water, certain bodies will not be so apt to sink in sea water as in rivers. If a ship, for example, were laden at Sunderland, Hartlepool, Whitby, or any other sea-port, with as much coals, corn, or other articles as it can possibly carry, it might move on in safety till it reached the fresh water in the Thames, and there it would infallibly sink to the bottom unless some of the cargo were discharged. Sea water may be reckoned at an average about one thirty-third part heavier than river water; and this might serve as a guide to the master of a ship, who wished to take in as weighty a cargo as possible. Suppose 200 tons to be the heaviest cargo with which the ship might easily float on the sea, had he the prospect of ascending a river to unload his vessel, he could not with safety take in more than 194 tons, or he should discharge six tons before he entered the river.

It is on principles similar to those which we have now illustrated

that fishes swim, and elevate and depress themselves alternately in the water. They possess a faculty of varying at pleasure the specific gravity of their bodies, which they are enabled to accomplish by means of a bladder, usually double, known by the name of the *air bladder,* and which is generally placed above the abdominal viscera. A little pneumatic canal, which establishes a communication between the vent and the bladder, enables the fish to introduce into this species of bag an aeriform fluid, which varies in its nature according to the different kinds of fishes. The vessel or bag dilated by this air produces in the fish an augmentation of volume, causing it to be specifically lighter than the water, so that it raises itself in the fluid without the intervention of the organs of motion: and when it would descend, nothing more is requisite than to expel sufficient air from its bladder, to occasion such a diminution of volume as will render it heavier than the volume of water which it displaces. This construction of a fish shows the wisdom of the Creator in adapting it to the element in which it is to pass its existence, and likewise the natural instinct or sagacity of the animal in applying its powers for the purpose of directing and regulating its movements.



FISH LIVING AND DEAD.

Hydraulics.

THE science of hydraulics teaches how to estimate the velocity and force of fluids in motion. It may be considered as a branch of hydrostatics. On the principles of this science all machines worked by water are constructed, and several engines used in the mechanical arts.—It would be too tedious to enter minutely into this subject, and therefore I shall offer only an illustration or two of its principles.

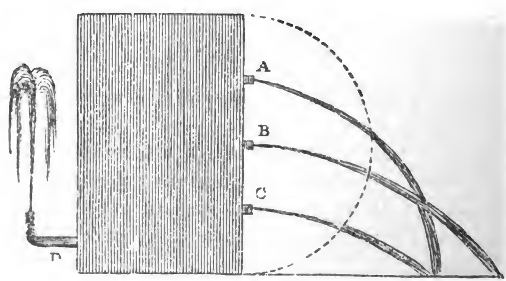
It has been generally considered an inquiry of some importance to know the causes by which water spouts from vessels to different heights and distances. We observe, for instance, that when an open vessel of liquor upon its stand is pierced at the bottom, the liquor, when the opening is first made, spouts out with great force; but, as it continues to run, becomes less violent, and the liquor

flows more feebly. A knowledge of hydraulics instructs us in the cause of this diminution of its strength; it shows precisely how far the liquor will spout from any vessel, and how fast and in what quantities it will flow. Upon the principles elicited by this science, various kinds of mills, pumps, fountains, and other machines are constructed and their theory explained. The following is one of the important theorems or principles in hydraulics:—

The velocity with which water spouts out at a hole in the side or bottom of a vessel, is as the square root of the depth or distance of the hole below the surface of the water.

For, in order to make double the quantity of a fluid run through one hole, as through another of the same size, it will require four times the pressure of the other, and therefore must be four times the depth of the other below the surface of the water. For the same reason, three times the quantity running in an equal time through the same sort of hole, must run with three times the velocity, which will require nine times the pressure, and consequently must be nine times as deep below the surface of the fluid; and so on for other proportions.—In order to show the different quantities and velocities of water spouting at different distances from the surface of a reservoir, a vessel such as that represented in Fig. 26, may be used. The water will issue from

FIG. 26.



the orifice at C with greater velocity, and consequently in greater quantity than at B or A. If the orifice C be four times as deep below the surface as the orifice A, it will discharge twice as much water in a given time as A, because two is the square root of four.

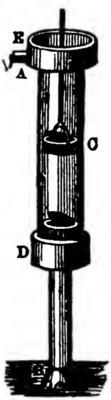
If a cup that holds an English pint were placed so as to receive the water that spouts from the pipe A, and at the same moment a cup that holds a quart were so placed as to receive the water that spouts from the pipe C, both cups would be filled at the same time by their respective pipes,—supposing water to be constantly poured into the vessel to keep the surface still at the same height.

The horizontal distance to which a fluid will spout from a horizontal pipe in any part of the side of an upright vessel below the surface of the fluid is equal to twice the length of a perpendicular to the side of the vessel, drawn from the mouth of the pipe to a semicircle described upon the altitude of the fluid; and therefore the fluid will spout to the greatest distance possible from a pipe whose mouth is the centre of the semicircle; because a perpendicular to its diameter drawn from that point is the longest that can be drawn from any part of the diameter to the circumference of the semicircle. Thus, if the vessel represented in the figure be full of water, and the horizontal pipe B in the middle of its side, and the semicircle be described on B as a centre, the perpendicular from that point to the diameter is the longest that can be drawn from any part of the diameter to the circumference. If, therefore, the vessel be kept full, the jet B will spout from the pipe B to a horizontal distance which is double the length of the perpendicular; and if two other pipes, C and A, be fixed into the side of the vessel, at equal distances above and below the pipe B, the perpendiculars from these pipes will be equal, and the jets spouting from them will each go to a horizontal distance which is double the length of either the equal perpendiculars drawn from these pipes to the semicircle. Consequently the pipe or orifice B in the centre of the column of water will project the fluid to the greatest horizontal distance.—The vessel here represented may be made either of wood or of tinplate; and if a bent tube be inserted at D, and the holes A B C shut up, it may serve to exhibit a *jet d'eau.*

As our limits prevent us from prosecuting this subject much farther, we shall just give a brief description of the *common or sucking pump,* the action of which depends partly on hydrostatical and partly on pneumatical principles.—There are three kinds of pumps, namely, the *sucking,* the *lifting,* and the *forcing* pump. By the two last water may now be raised to any height with an adequate apparatus and sufficient power; but by the sucking pump it can be raised only about thirty-two or thirty-three feet above the surface of the water

The body of a common pump consists of a large tube or pipe whose lower end is immersed in the water which it is designed to raise. A kind of stopper called a piston, is fitted to this tube, and is made to slide up and down in it by means of a metallic rod fastened to the centre of a piston. This pump is represented in Figure 27, where A B represents a pipe open at both ends. In this is a moveable cylinder or *piston* C, which works in the bore of the pipe. The piston is made so as to fit the bore exactly, by leathers or other means, to prevent the air from passing between it and the sides of the pump. There is a valve in the piston which opens upwards like a trap door, for the purpose of permitting the air and the water to ascend through it, but to prevent them from returning. The first and wider part of the pump is called the *barrel*, and the other part D B is called the *suction-pipe*, and is of a smaller diameter. At the joining of the barrel with the suction-pipe there is a fixed valve D, opening also upwards. The lower end of the suction-pipe is immersed in the water, which runs into it through small holes at B; and at the top of the barrel is a wide head, and a pipe E for letting out the water which has been raised by the pressure of the atmosphere and the working of the pump.

FIG. 27.



When the pump is in a state of inaction, the piston C is closed down upon the fixed valve D, and both valves remain shut by their own weight. In drawing up the piston from D to C a vacuum of air is found in that space; consequently, the air in the rest of the pipe from D to B will force its way through the valvé D, and fill the part which had been exhausted. The water, then, relieved from the pressure of the air, ascends into the pump. A few strokes of the handle totally excludes the air from the body of the pump, and fills it with water, which, having passed through both the valves, runs out at the spout. By alternately raising and depressing the pistons, this effect is produced; every time the bucket is raised, the valve D rises, and the valve C falls; and at every time the bucket is depressed, the valve D falls and C rises; and thus a stream will be produced which continues so long as the operation is performed. If, at the beginning of the operation, the leathers be dry, the piston C will not exhaust the air sufficiently, and the water will refuse to rise; but if a cer-

tain quantity of water be poured upon the piston, it will swell the leathers, causing them to fit closely, and then the piston will act.

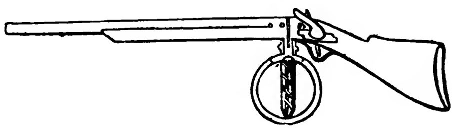
The pump is said to have been invented by a mathematician named Ctesebes, about 120 years before Christ, but the principle on which it acts appears to have been unknown till the seventeenth century. About that time some workmen were employed by the duke of Florence to raise water by a common sucking pump to the height of fifty or sixty feet. A pump was accordingly constructed for that purpose; but after all their efforts, they were unable to raise it above the height of thirty-two feet. The matter was referred for explanation to the famous astronomer and philosopher Galileo; but, strange to tell, he was unable to solve the difficulty. This difficulty is now very easily explained, when we take into account the pressure of the atmosphere. The water is raised by pumps in consequence of the elasticity of the pressure of the atmosphere; and the reason why it can be raised only to about thirty-two feet in common pumps is, because the force of the atmosphere is equal only to a column of water about thirty-two feet in height.

Pneumatics.

This branch of philosophy treats of the nature and properties of the atmosphere, and of their effects, on solid and fluid bodies. From this science we learn that air has *weight*, and presses on all sides like other fluids; that the pressure of the atmosphere on the top of a mountain is less than on the plain beneath; that it presses upon our bodies with a weight of several thousand pounds more at one time than at another; that air can be compressed into forty thousand times less space than it naturally occupies; that it is of an elastic or expansive nature, and that the force of its spring is equal to its weight; that its elasticity is increased by heat; that it is necessary to the production of sound, the support of flame and animal life, and the germination and growth of all kinds of vegetables.

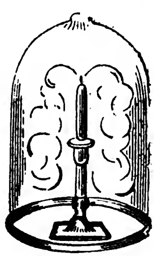
These positions are proved and illustrated by such experiments as the following:—The general *pressure* of the atmosphere is proved by such experiments as those detailed in Note II. of the Appendix. The following experiment proves that air is *compressible*. If a glass tube, open at one end, and close at the other, be plunged, with the open end downwards, into a tumbler of water, the water will rise a little way in the tube; which shows, that the air which

filled the tube is compressed by the water into a smaller space. The *elasticity* of air is proved by tying up a bladder, with a very small quantity of air within it, and putting it under the receiver of an air-pump, when it will be seen gradually to inflate, till it becomes of its full size. A similar effect would take place by carrying the bladder to the higher regions of the atmosphere. On the compression and elasticity of the air depends the construction of that dangerous and destructive instrument, the Air-gun. That



AIR-GUN.

it is capable of being ratified by heat, is proved by holding to the fire a half-blown bladder, slightly tied at the neck, when it will dilate to nearly its full size; and if either a *full-blown* bladder, or a thin glass bubble filled with air, is held to a strong fire, it will burst. The elasticity of the air is such that Mr. Boyle, by means of an air-pump, caused it to dilate till it occupied fourteen thousand times the space that it usually does. That the air is necessary to sound, flame, animal and vegetable life, is proved by the following experiments:—When the receiver of an air-pump is exhausted of its air, a cat, a mouse, or a bird, placed in it, expires in a few moments, in the greatest agonies. A bell rung in the same situation produces no sound; and a lighted candle is instantly extinguished. Similar experiments prove that air is necessary for the flight of birds, the ascent of smoke and vapours, the explosion of gunpowder, and the growth of plants; and that all bodies descend equally swift in a place void of air; a guinea and a feather being found to fall to the bottom of an exhausted receiver at the same instant.



SMOKE DESCENDING IN VACUO.

On the principle of this science the BAROMETER, or *Weather-Glass*, is constructed. If a glass tube, about thirty-three inches long, and hermetically sealed at one end, be filled with mercury, and then inverted into a basin of the same fluid, the mercury in the tube will stand at an altitude above the surface of that in the

basin, between twenty-eight and thirty-one inches. When a tube is thus filled, and *graduated* from twenty-eight to thirty-one inches, it derives the name of a *Barometer* or Weather-glass. Opposite the graduated part of this instrument the following words are generally engraved on the common barometer. At thirty-one inches, *Very Dry,*—at thirty-and-a half, *Set Fair,*—at thirty, *Fair,*—at twenty-nine-and-a-half, inches, *Changeable,*—at twenty-nine inches, *Rain,*—at twenty-eight-and-a-half inches, *Much Rain,*—at twenty-eight inches, *Stormy.* As the atmosphere varies in its density at different times, the surface of the mercury in the tube will be sometimes at one elevation, and sometimes at another; and the different elevations of the mercury were supposed to correspond to certain changes of the weather. But the changes of the weather indicated by the different heights of the mercury are not always found to correspond with the *words* marked on the scale of the barometer. It is very seldom that the mercury descends so low as *Stormy,* or rises so high as *Set Fair.* Its more ordinary range is from *Rain* to *Fair.*

The Barometer, as its name denotes, is an instrument for measuring *the weight* of the atmosphere; and as the atmosphere varies in its pressure, it indicates the *variations* which take place in its weight or pressure, which are found to be generally accompanied with changes in the weather. As a cubic inch of water weighs 253·18 grains Troy, a cubic inch of air weighs 0·288 grains; and if mercury be fourteen times heavier than water, the specific gravity of air is to that of mercury as 1 to 885x 14=12,390; that is, mercury is twelve thousand three hundred and ninety times heavier than air in its general state at the surface of the earth. Now, the mercury in the tube of the barometer will subside till the column be equivalent to the weight of the external air upon the surface of the mercury in the basin, and is therefore a true criterion to measure that weight. When the mercury stands at thirty inches, it shows that a column of mercury thirty inches long balances a similar column of air the whole height of the atmosphere. Therefore, if the air were equally dense at all heights of the atmosphere, to its top, its height, or elevation above the earth, would be, 12,390 times

THE BAROMETER.

thirty inches=371,700 inches, which are equal to five miles and 1524 yards. This would be the height of the atmosphere, were it equally dense in all its parts: but it is found that the air, by its elastic quality, expands and contracts, so that at three-and-a-half miles above the surface of the earth, it is twice as rare as its surface; at seven miles it is four times rarer; at ten-and-a-half miles, eight times rarer; at fourteen miles, sixteen times rarer, etc. In this way, therefore, the real height of the atmosphere cannot be determined. But, from experiment and calculation, it is found that the atmosphere at the height of more than forty-five miles above the earth's surface is not sufficiently dense to refract the rays of light, and consequently this is generally reckoned the height of the atmosphere.

The following are some rules, founded on numerous observations, which have been given for judging of the state of the weather from the variations of the barometer:—

1. The rising of the mercury presages in general *fair* weather; and its falling *foul* weather, as rain, snow, high winds and storms. When the surface of the mercury is convex, or stands higher in the middle than at the sides, it is a sign that the mercury is then in a rising state; but if the surface be concave or hollow in the middle, it is then sinking.

2. In very hot weather the falling of the mercury denotes thunder. Storms of thunder most frequently happen when the mercury stands at *Changeable*, or a little below or above it.

3. In winter, the rising of the mercury presages frost; and in frosty weather, if it fall three or four divisions, there will be a thaw. But in a continued frost, if the mercury rise, it will certainly snow.

4. When wet weather happens soon after the falling of the mercury, expect but little of it: on the contrary, expect but little fair weather when it proves fair shortly after it has risen.

5. In wet weather, when the mercury rises much and high, and continues so for two or three days before the rain is entirely over, a continuance of fair weather may be expected.

6. The unsettled motion of the mercury denotes unsettled weather.

7. In fair weather, when the mercury falls much and low, and thus continues for two or three days before the rain comes, then a great deal of wet weather may be expected and probably high winds.

8. In winter, spring, and autumn, the sudden falling of the mercury, and that for a large space, denotes high winds and storms; but in summer, it presages heavy showers, and frequently thunder. It sinks lowest of all for great winds, though not accompanied with rain, but it falls more for wind and rain together than for either of them alone.

9. If, after rain, the wind change into any part of the north, with a clear and dry sky, and the mercury rise, it is a certain sign of fair weather.

10. After very great storms of wind, when the mercury has been low, it generally rises again very fast.—In settled fair weather, except the barometer sink much, expect but little rain.—In a *wet season*, the smallest depressions must be attended to; for when the air is much inclined to showers, a little sinking in the mercury denotes more rain. And in such a season, if it rise suddenly fast and high, fair weather cannot be expected to last more than a day or two.

11. The words engraved on the scale of the barometer are not so much to be attended to as the rising and falling of the mercury; for, if it stand at *Much Rain*, and then rise to *Changeable*, it denotes fair weather, though not to continue so long as if the mercury had risen higher. If the mercury stands at *Fair* and falls to *Changeable*, bad weather may be expected.

The greatest heights of the mercury are found during the prevalence of easterly and north-easterly winds; and it may often rain or snow—the wind being in these points—while the barometer is in a rising state, the effects of the wind counteracting. But the mercury sinks for wind as well as rain in all other points of the Compass.—From these observations it appears that it is not so much the height of the mercury in the tube that indicates the weather as its motion upwards or downwards. In the torrid zone the mercury seldom either rises or falls so much as in our climate.

The barometer is an instrument which has likewise been applied to *the measuring of heights*. As we ascend into the higher regions of the atmosphere, we find that the air is rarer than at the surface of the earth, and its pressure, consequently, is less. If in ascending a mountain we take a barometer along with us, we shall find that the mercury gradually sinks in proportion to the elevation we have attained. And from numerous observations and calculations,

it has been determined at what rate the barometer sinks for every hundred feet of elevation. For example, in ascending the Puy de Dome, a high mountain in the Alps, the mercury in the barometer fell three and a half inches; and the height of the mountain was found by measurement to be 3204 feet. By a similar experiment made on the top of Snowdon, in Wales, the mercury was found to fall three inches and eight-tenths at the height of 3720 feet above the surface of the earth. From these and similar observations it has been inferred that, in ascending any lofty eminence, the mercury in the barometer will fall about one-tenth of an inch for every hundred feet of perpendicular ascent. This number is only an approximation to the truth; but may be sufficiently exact for ordinary purposes, where great accuracy is not required.

Taking the proportion now stated as nearly correct—were we to ascend an eminence, and find that the mercury had fallen one inch, we might then infer that we had ascended to an elevation, about a thousand feet in height. It is in this way that an Aeronaut, when ascending the atmosphere in a baloon is enabled to determine the altitude above the earth to which he has risen.

Connected with the atmosphere and evaporation, is *the formation of* Clouds. Evaporation is the process by which water is converted into vapour, which being specifically lighter than the atmosphere, is raised above the surface of the earth, and afterwards, by a partial condensation, forms those masses that float above us which we call *clouds.* They differ from fogs only by their height and their less degree of transparency. The cause of this latter circumstance is the thinness of the atmosphere in its higher regions where the particles of vapour become condensed. The varieties of clouds are numerous. Some cast a shade that covers the sky, and at times produce a considerable darkness; others resemble a light veil, and permit the rays of the sun and moon to pass through them. The watery evaporations which rise from seas, lakes, ponds, rivers, and in fact from the whole surface of the earth, ascend, on account of their elasticity and lightness, in the atmosphere, till the air becomes so cold and thin that they can rise no higher, but are condensed, and fall down in rain.—Various opinions have prevailed among philosophers, as to the causes which operate in the

formation of clouds, and the manner in which they are condensed into rain. De Luc supposes that water, after its ascent in the form of vapour, and before it takes the shape of clouds, exists in a gaseous state, and he explains the clouds to be collections of small vesicles, in the transformation of which from the gaseous state, he believes that caloric, or the principle of heat, operates in part at least, because according to his opinion, clouds communicate a degree of heat to the body which they render damp. Others suppose that electricity is one principal agent in the formation of clouds. It is certain that, in many instances, they contain a prodigious quantity of electricity, and many terrible and destructive effects have been produced by them when in this state. But though it is certain that all clouds or even fogs and rain are electrified in some degree, it still remains a question whether the clouds are formed in consequence of the vapour of which they are composed being first electrified, or whether they become electrified in consequence of its being first separated from the atmosphere, and in some measure condensed. In short, the formation of clouds, and the various changes and modifications which take place before they are condensed into rain cannot as yet be said to have been fully ascertained. As Goldsmith remarks, "Every cloud that moves, and every shower that falls, serves to mortify the philosopher's pride, and to show him hidden qualities in air and water, that he finds it difficult to explain."

The change of winds, among other causes, contributes essentially to the formation of clouds and fogs. In countries where this change is small and infrequent, as between the tropics, these phenomena of humidity must be comparatively rare; but when they do happen, they are the more violent, because a great quantity of vapour has had time to collect. Hence it happens in tropical climes, after a long period of dry weather and serene skies, when the clouds collect, they remain for weeks, and sometimes for months, covering the face of the heavens, and pouring down torrents of rain accompanied with thunder and lightning, and violent tornadoes.

The *distance of the clouds* from the surface of the earth is different at different times. Thin and light clouds are higher than the highest mountains; thick and heavy clouds, on the contrary, sometimes touch low mountains, steeples, and even trees. The average height of the clouds is generally reckoned to be about two miles

and a half. Their size is likewise very different. Some have been found occupying an extent of twenty square miles; and their thickness, in some cases, has been ascertained by travellers who have ascended high mountains, to be a thousand feet: Others are very thin and of small dimensions. The tops of very high mountains are frequently above the level of the general range of the clouds, so that the traveller who ascends to their summits frequently beholds the clouds and the tempests raging far beneath him, while all appears serene and calm in the blue firmament above. Clouds that are highly electrified descend lowest, their height being frequently not above seven or eight hundred yards above the ground; nay, sometimes thunder-clouds appear actually to touch the ground with one of their edges.—In the evenings after sunset, and mornings before sunrise, we frequently observe the clouds tinged with beautiful colours. They are mostly red, sometimes orange, yellow, or purple, more rarely bluish, but seldom or never green. This is supposed to be owing to the clouds reflecting the sun's light precisely as it is transmitted to them through the atmosphere. The atmosphere reflects the most refrangible rays in the greatest quantity; and therefore ought to transmit the least refrangible ones—red, orange, and yellow—to the clouds, which accordingly appear most usually of those colours.

The *motions* of the clouds, though sometimes directed by the wind, are not always so, especially when thunder is about to ensue. In this case they seem to move very slowly, and frequently to be absolutely stationary for some time. The reason of this most probably is, that they are impelled by two opposite streams of air nearly of equal strength, by which their velocity is greatly retarded. In such cases, both the aërial currents seem to ascend to a very considerable height; for Messrs. Charles and Roberts, when endeavouring to avoid a thunder-cloud in one of their aërial voyages, could find no alteration in the course of the current, though they ascended to the height of 4000 feet from the surface of the earth. In some cases the motions of the clouds evidently depend on their electricity, independently of any current of air whatever. Thus, in a calm and warm day, we often see small clouds meeting each other in opposite directions, and setting out from such short distances, that we cannot suppose any opposite winds to be the cause. These clouds, when they meet, instead of forming a larger one, become much

less, and sometimes vanish altogether; a circumstance undoubtedly owing to the discharge of opposite electricities into each other.—The *shapes* of the clouds are likewise undoubtedly owing to their electricity; for in those seasons in which a great commotion has been excited in the atmospherical electricity, we perceive the clouds assuming strange and whimsical shapes, which vary almost every moment. This, as well as the meeting of small clouds in the air, and vanishing upon contact, is an almost infallible sign of thunder.

Artificial Distinction or Classification of Clouds.—There are three general distinctions or modifications of clouds which are now recognized by Naturalists,—the Cirrus, the Cumulus, and the Stratus. The *Cirrus* is a cloud which appears to have the least density, and generally the greatest elevation, and the greatest variety of extent and direction, and its figure is very rapidly and frequently changed. After a continuance of clear weather, the cirrus is frequently the first cloud that is seen It looks like a fine whitish thread pencilled on the clear blue sky, and other faint lines of the same kind are added laterally. They increase in size and length, and often serve as stems from which numerous branches proceed, and become other cirri of the same kind.—They are generally very high in the air; they do not always extend in parallel lines, but frequently diverge, or encrease obliquely down wards. Sometimes it happens that transverse lines are formed, giving to the sky the appearance of being covered with a beautiful curtain of net work. In some kinds of weather these clouds frequently present to the eye numberless and ever-changing figures. Their duration is uncertain, varying from a few minutes after their first appearance to an extent of many hours. It is long when they appear alone, and at great heights, and shorter when they are formed lower, and in the vicinity of other clouds. This species of cloud is generally supposed to be a conductor of the electric fluid.

The Cumulus is generally of the most dense structure, consisting of a convex aggregate of watery particles, encreasing upwards from a horizontal base. It is formed in the lower part of the atmosphere, and moves along in the current of wind which is next to the earth. When first seen, its appearance is that of a small irregular spot, which increases in size, preserves a flat horizontal base, and assumes more or less of a conical figure. Those clouds vary in

shape and dimensions according to the causes which produce them. Sometimes they are well defined hemispherical masses; at other times they rise into mountains ranged in one plane, and with their white silvery summits, present an august and beautiful appearance. Before rain they increase very rapidly, descend lower in the atmosphere, and become fleecy and irregular in their appearance, with their surfaces full of protuberances. In changeable weather, they evaporate almost as soon as formed, or quickly change into other modifications; but in fair weather they keep pace with the diurnal temperature. They are seen to form soon after sun-rise, arrive at their maximum about mid-day, when they become convenient screens to intercept the solar rays, and they generally subside in the evening a little before or after sun-set. This circumstance requires to be attended to by the astronomer when intending to view the solar spots; for if, in a clear morning, he defer his observations till noon or afternoon, he will very likely be disappointed by the interposition of these clouds. The formation of large cumuli to lee-ward in a strong wind indicates the approach of a calm with rain. When they do not disappear about sun-set, but continue to rise, thunder may be expected in the night.

The STRATUS.—This is among the densest and the lowest of the clouds. Its lower surface usually rests on the earth or on the water. It is properly the cloud of night, as the time of its appearance is about sun-set, and it disappears soon after sun-rise. When ascending in the atmosphere, it often seems at a certain elevation to become a cumulus. It comprehends what we usually call fogs and mists, which in fine summer evenings are seen to ascend in spreading sheets from valleys, fields, and lakes; and which, in winter and autumn, sometimes continue through the day as dense fogs.

Besides the above general divisions of the clouds, there are certain subordinate divisions into which they have been arranged, distinguished by the following terms: *Cirro-cumulus, Cirro-stratus, Cumulo-stratus, Nimbus* or *Cumulo-cirro-stratus.*

After the cirrus has continued for sometime encreasing it usually passes into the *Cirro-cumulus,* or the *Cirro-stratus,* at the same time descending to a lower station in the atmosphere. The cirro-cumulus is formed from a cirrus or from a number of small separate cirri, by the fibres collapsing as it were, and passing into small roundish masses in which the texture of the cirrus is no longer dis-

FORM OF CLOUDS.

cernible. This configuration of the clouds is very common in summer, and frequently forms very beautiful skies. These cirro-cumuli are seen floating gently along in different altitudes, and consist of numerous distant beds of small roundish connected clouds, presenting what is generally called a *dappled* sky. Such clouds are generally attendant on warm and dry weather. They are occasionally seen in winter, and in the intervals of showers; they are a sure prognostic of encreased temperature.

The *Cirro-stratus* results from the subsidence of the fibres of the cirrus to a horizontal position, at the same time that they approach each other laterally. This cloud descends lower in the atmosphere than the cirrus, its fibres become denser and more regularly horizontal. Its figure is very various, sometimes it consists in dense longitudinal streaks; at others it looks like shoals of fish; sometimes the whole sky is so mottled with it, as to give the idea of the back of the mackerel, which is called the mackerel-backed sky. It is remarkable for exhibiting a great variety of beautiful colours, particularly in the morning and evening, when the sun is near the horizon. It precedes wind and rain, the near or distant approach of which may sometimes be estimated from its greater or less abundance or permanence. It is almost always to be seen in the intervals of storms.

The *Cumulo-stratus* is formed in the interval between the first appearance of the fleecy cumulus and the commencement of rain; also during the approach of a thunder-cloud. The cumulus, losing its hemispherical figure, encreases irregularly upward, grows more dense, and overhangs its base in uneven or rugged folds. This cloud varies its appearance at different times. Sometimes it appears as a large lofty dense cloud overhanging a perpendicular stem, and looks like a great mushroom. Frequently a long range of cumulo-strati appears together, which presents the aspect of a chain of mountains with silvery tops, appearing sometimes like mountains covered with snow, intersected with dark ridges, and lakes of water, rocks, and towers. This happens more especially in the torrid zones. Before thunder-storms it seems frequently reddish, which some have imagined to rise from its being highly charged with the electric fluid.

The *Nimbus*, or rain cloud. Before rain takes place, the clouds are uniformly found to undergo a change, attended with appearances sufficiently remarkable to indicate this as a distinct modi-

fication of clouds. This change is supposed to consist in the uniting of particles of water differently electrified, which, having a mutual attraction for each other, closely unite, forming visible drops of water, which therefore gravitate and descend in rain. The following changes are what frequently happens in the rapid production of showers. The cumulus, moving along in a low region of the atmosphere, appears retarded in its progress, encreases upwards, and inosculates with a cirrus or cirro-stratus above; then the whole changes into a cumulo-stratus, and spreads horizontally, forming a dense sheet: a sort of crown of cirrose fibres extends upwards from the superior part, while loose flocky cumuli, entering from below, seem to nourish the growing nimbus, which, increasing in density, at length descends in rain, the drops or streams of which appear to acquire magnitude in their progress to the earth. After the storm has spent itself, the mass is again disunited, and formed into the different modifications.[1] Among clouds the cirrus is reckoned the highest, the cirro-cumulus next; and the cirro-stratus, cumulus, and stratus, successively lower than each other. The *nimbus*, which resolves the clouds into rain, may be considered as the lowest.

Clouds, highly charged with electricity, not only produce violent storms of thunder and lightning, but sometimes are the cause of the most dreadful devastations. Of this we have a striking instance, which occurred in the island of Malta, on the 29th of October, 1757, as related by Mr. Brydone in the 1st vol. of his 'Tour through Sicily and Malta.'

"About three quarters of an hour after midnight there appeared to the south-west of the city a great black cloud, which, as it approached, changed its colours, till at last it became like a flame of fire mixed with black smoke. A dreadful noise was heard on its approach, that alarmed the whole city. It passed over part of the port, and came first upon an English ship, which in an instant was torn to pieces, and nothing left but the hulk; part of the masts, sails, and cordage were carried along with the cloud to a considerable distance. The small boats and fellouques that fell in its way were all broken to pieces and sunk. The noise increased and became more frightful. A sentinel, terrified at its approach, ran

[1] Several of the preceding descriptions of the modifications of the clouds have been selected and abridged from Forster's 'Researches about Atmospherical Phenomena.'

into his box: Both he and it were lifted up and carried into the sea, where he perished. It then traversed a considerable part of the city, and laid in ruins almost every thing that lay in its way. Several houses were laid level with the ground, and it did not leave one steeple in its passage. The bells of some of them, together with the spires, were carried to a considerable distance. The roofs of the churches were demolished and beat down, which, if it had happened in the day-time, must have had dreadful consequences, as all the people would immediately have run to the churches. It went off at the north-east point of the city; and, demolishing the light-house, is said to have mounted up in the air with a frightful noise, and passed over the sea to Sicily, where it tore up some trees and did other damage, but nothing considerable, as its fury had been mostly spent upon Malta. The number of killed and wounded amounted to nearly 200; and the loss of shipping and houses was very considerable."—The people of Malta declared with one voice that it was a legion of devils let loose to punish them for their sins, and that, had there not been a few godly people amongst them, their whole city would certainly have been involved in one universal destruction.

Many other illustrations might have been given of subjects connected with pneumatics, did our limits permit further enlargement. —On the principles which this science has established have been constructed the air-pump, the thermometer, the diving bell, the hydrometer, the condenser, the rain guage, and various other instruments that have contributed to the comfort of human life, and the enlargement of our knowledge of the constitution of nature.

Acoustics.

This science treats of the nature, the phenomena, and the laws of *sound*, and the theory of musical concord and harmony. From the experiments which have been made on this subject, we learn, that air is essential to the production of sound; that it arises from *vibrations* in the air, communicated to it by vibrations of the sounding body; that these vibrations, or aërial pulses, are propagated all round in a spherical undulatory manner; that their density decreases as the squares of the distances from the sounding body encrease; that they are propagated together in great numbers

from different bodies, without disturbance or confusion, as is evident from concerts of musical instruments; that water, timber, and smooth walls, are also good conductors of sound; that sound travels at the rate of 1142 feet in a second, or about thirteen miles in a minute;[1] that the softest whisper flies as fast as the loudest thunder; and that the utmost limits, within which the loudest sounds, produced by artificial means, can be heard, is 180 or 200 miles;[2] that sound, striking against an obstacle, as the wall of a house, may, like light, be reflected, and produce another sound, which is called an *echo;* and that, after it has been reflected from several places, it may be collected into one point or focus, where it will be more audible than in any other place.

The following are some of the phenomena connected with *echoes.* 1. A *plane* obstacle reflects the sound back in its due tone and loudness; allowance being made for the proportional decrease of the sound according to its distance. 2. A *convex* obstacle reflects the sound somewhat smaller, and quicker—though weaker than it otherwise would be. 3. A *concave* obstacle echoes back the sound louder, slower, and also inverted; but never according to the order of words. 4. The echoing body being removed farther off, reflects more of the sound than when nearer, which is the reason why some echoes repeat but one syllable, some one word, and some many. 5. Echoing bodies may be so contrived and placed, that reflecting the sound from one to the other, either directly and mutually, or obliquely and by succession, out of one sound, a

[1] The velocity of sound has been somewhat differently estimated by different experimenters. Mr. Boyle estimated its velocity at 1200 feet; the Florentine Academicans at 1148; the French Academicans at 1172 feet per second. It is reckoned by some modern philosophers that 1120 feet per second may be reckoned as a medium estimate. The experiments of Flamstead, Halley, and Derham, which were considered as having been accurately performed, give 1142 feet per second as the average velocity of sound—which is sometimes modified by the direction of the wind and local circumstances.

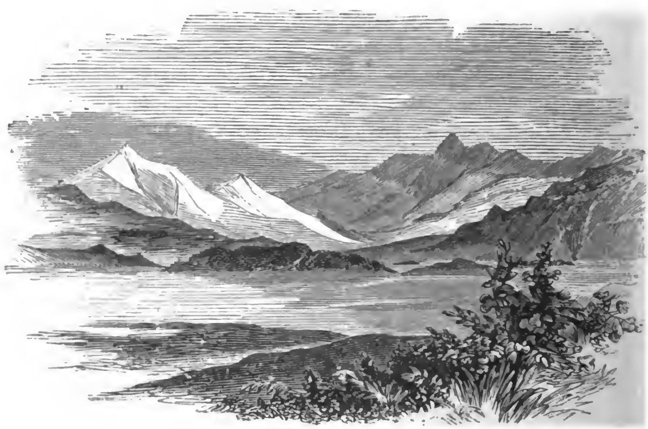
[2] In the war between England and Holland, in 1672, the noise of the guns was heard in those parts of Wales which were estimated to be two hundred miles distant from the scene of action. But the sounds produced by volcanoes have been heard at a much greater distance; some instances of which are stated in Chap. IV. Sect. 2. A French savan has also made some experiments on the weather from the vibrations of the air, caused by the bombardment of Sebastopol. Several other facts, in relation to sound, are detailed in Chap. III, Art. *Acoustic Tunnels.*

multiple echo, or many echoes shall arise. A multiple echo may be made by so placing the echoing bodies at unequal distances that they may reflect all one way, and not one on the other, by which means a manifold successive sound will be heard; one clap of the hands like many; one *ha*, like laughter; one single word like many of the same tone and accent, and so one viol, like many of the same kind, imitating each other. 6. Echoing bodies may be so ordered that from any one sound given they shall produce many echoes different both as to tone and intensity. By which means a musical room might be so contrived that not only *one* instrument playing in it shall seem *many* of the same sort and size, but even a concert of different ones—only by placing echoing bodies so, that any note played shall be returned by them in 3rds, 5ths, and 8ths.

Echoes are found for the most part in caverns, grottos, and ruined abbeys. They reverberate in the areas of antique halls, in the windings of long passages, in the aisles of arched cathedrals, and not unfrequently among mountain ranges, and the icebergs of the Arctic seas.—The following are some of the more remarkable echoes which have been noted by various writers:—

In the sepulchre of Metella, the wife of Crassus, there was an echo which repeated five different times in five different keys what a man said. At a tower in Cyzicus there is said to be an echo where the sound is repeated seven times. At Woodstock there was an echo which returned seventeen syllables during the day, and twenty during night. One of the finest echoes we read of is that mentioned by Barthias, which repeated seventeen times the words a man uttered. This echo was on the banks of the Naha, between Coblentz and Bingen. Whereas in other echoes the sound is not heard till some time after hearing the word spoken, or the notes sung;—in this, the person who speaks or sings is scarcely heard at all; but the repetition most clearly, and always in surprising varieties; the echo seeming sometimes to approach nearer, and sometimes to be farther off. Sometimes the voice is heard very distinctly, and sometimes scarcely at all. One hears only one voice and another several; one hears echo on the right, and another on the left, and in general the responses were loud and distinct, clear and various.—In the cemetery of the Abercorn family, at Paisley, in the county of Renfrew, there is an echo exceedingly striking and romantic. When the door of the chapel is

closed with any degree of violence, the reverberations are equal to the sounds of thunder. Breathe a single note of music, and the tone ascends gradually, with a multitude of echoes, till it dies in soft and bewitching numbers.—At Milan, in Italy, is an echo which reiterates the report of a pistol fifty-six times, and if the report is very loud, upwards of sixty reiterations may be counted. The first twenty echoes are pretty distinct; but as the noise seems to fly away, and to answer at a greater distance, the reiterations are so doubled that they can scarcely be counted. A singular echo is also heard in a grotto near Castle Comber in Ireland. No reverberation is heard till the listener is within fifteen or sixteen feet of the extremity of the grotto; at which place a delightful echo enchants the ear.—On the banks of the Lake of Killarney



LAKE OF KILLARNEY.

there is an echo called the "Eagles' Nest." This celebrated rock sends forth the most fascinating repercussions. Sound a French or bugle-horn, and echoes equal to a hundred instruments answer to the call. Fire a single cannon, and the loudest thunder reverberates from the rock, and dies in endless peals along the distant mountains.—In the Baptistry of St. Giovanne del Battesimo was an echo that repeated a note of music six times; and there is one

between Conflans and Charrenton which repeats ten times. In the garden of the Tuileries at Paris, there is an artificial echo which is said to repeat a whole verse without the loss of a syllable. Among the hermitages of Montserrat, particularly near that of Santissimo, Trinidad, the rocks are said to produce so many echoes that the birds warble an answer to their own reverberations.[1]

Echoes are said to have multiplied every sound in the grotto of Delphi, famous for its temple and oracles: they increased the veneration and the curiosity which prompted thousands to visit the temple of Apollo; and doubtless aided the deceptions which were practised by the priests who ministered in that magnificent sanctuary of heathen oracles. There can be little doubt that the aid of echoes has frequently been employed in different ages, by designing priests and other impostors, to deceive the ignorant, and to promote the design of superstition and divination.

The intensity of sound increases or diminishes when the elasticity of the air encreases or diminishes, either by heat or by compression. Hence, in proportion as the air is rarified under the receiver of an air-pump, or in the ascent of lofty mountains, sound loses its force. Air communicates its vibrations to the sonorous bodies with which it is in contact. Hence a string of an instrument causes another stretched beside it to vibrate. A noise without makes the windows of an apartment to resound, and the discharge of cannons and peals of thunder cause buildings and even whole villages to shake. Euler tells us of a man who, by different inflections of his voice, made a glass vibrate so as almost to break it.—When the velocity of sound is known, the distance of certain objects may be determined. If a flash of a gun be observed, and the number of seconds or pulsations which elapse between seeing the flash and hearing the report be counted, this number multiplied by 1142, the assumed velocity of sound per second, will give the distance of the observer from the centre of vibration. If, in a thunder-storm, I can count five pulsations, from the instant of seeing the lightning till the report of the thunder be heard, the distance of the thunder-cloud will be $1142 \times 5 = 5710$ feet, that is, an English mile and 430 feet. Were the thunder to be heard within a second of the time of seeing the flash, it would indicate that the thunder was within 380 yards of the observer, and consequently, that he is within the

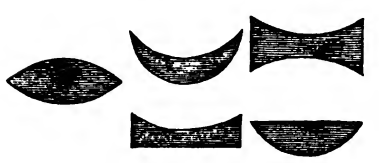
1 Bucke's Harmonies of Nature.

sphere of danger. In estimating such distances, four-and-a-half seconds, at an average, may be reckoned for every mile.

On the principles above stated we may account for the various phenomena of sounds and the diversified *echoes* which are heard in various places, which both amuse and sometimes puzzle the observers; and on the same principles whispering galleries, such as that in St. Paul's Church, London—speaking and hearing trumpets—wind and stringed instruments—the *Harmonica Celestina*, the *Æolian Harp*, and other acoustic instruments, are constructed.

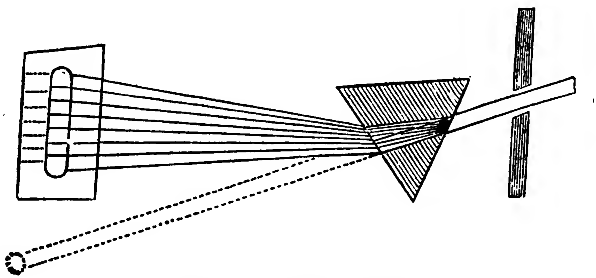
Optics.

This branch of philosophy treats of vision, light, and colours, and of the various phenomena of visible objects produced by the rays of light, reflected from mirrors, or transmitted through lenses. From this science we learn, that light flies at the rate of nearly twelve millions of miles every minute—that it moves in straight lines—that its particles may be several thousand of miles distant from each other—that every visible body emits particles of light from its surface, in all directions—that the particles of light are *exceedingly small;* for a lighted candle will fill a cubical space of two miles every way with its rays, before it has lost the least sensible part of its substance; and millions of rays, from a thousand objects, will pass through a hole not larger than the point of a needle, and convey to the mind an idea of the form, position, and colour of every individual object—that the intensity, or degree of light, decreases as the square of the distance from the luminous body encreases; that is, at two yards' distance from a candle we shall have only the fourth part of the light we should have at the distance of one yard; at three yards' distance, the ninth part; at four yards, the sixteenth part, and so on—that glass *lenses* may be ground into the following forms:—*plano-convex*, *plano-concave*, *double convex*, *double concave*, and *meniscus*, that is, convex on one side, and concave on the other—that specula, or mirrors, may be ground into either a spherical, parabolical, or cylindrical form—that, by means of such mirrors and lenses, the



LENSES.

rays of light may be so modified as to proceed either in a *diverging, converging*, or *parallel* direction, and the images of visible objects represented in a variety of new *forms, positions*, and *magnitudes*—that every ray of white light may be separated into seven primary colours: *red, orange, yellow, green, blue, indigo*, and *violet*—that the variegated colouring which appears on the face of nature is not in the objects themselves, but in the light which falls upon them—that the *rainbow* is produced by the refraction and reflection



DECOMPOSITION OF LIGHT.

of the solar rays in the drops of falling rain—that the rays of light are refracted, or bent out of their course, when they fall upon glass, water, and other mediums—that the light of the sun may be collected into a point or focus, and made to produce a heat more intense than that of a furnace,[1]—that the rays from visible objects,

[1] This is produced by means of lenses, or mirrors, of a large diameter, called burning-glasses. By these instruments, the hardest metals, on which common fires and even glass-house furnaces, could produce no effect, have been melted in a few seconds. M. Villette, a Frenchman, nearly a century ago, constructed a mirror, three feet eleven inches in diameter, and three feet two inches in focal distance, which melted *copper ore* in eight seconds, *iron ore* in twenty-four seconds, a fish's tooth in thirty-two seconds, *cast iron* in sixteen seconds, a silver sixpence in seven seconds, and *tin* in three seconds. This mirror condensed the solar rays 17,257 times, a degree of heat which is about *four hundred and ninety times* greater than a common fire. Mr. Parker, of London, constructed a lens three feet in diameter, and six feet eight inches focus, which weighed 212 pounds. It melted twenty grains of gold in four seconds, and ten grains of platina in three seconds. The power of burning-glasses is *as the area of the lens directly, and the square of the focal distance inversely*—or, in other words, the broader the mirror or lens, and the

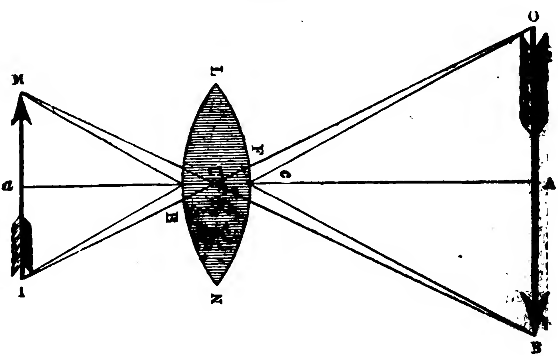
when reflected from a concave mirror, converge to a focus, and paint an image of the objects before it, and that when they pass through a convex glass, they depict an image behind it.

The formation of *images* by optical lenses and specula forms a very curious and important part of the science of optics, on which it might not be improper to offer a few reflections and remarks.

It is a remarkable circumstance, and which would naturally excite a high degree of admiration, were it not so well known, that, *When the rays of light from any object are refracted through a convex lens they paint a distinct and accurate picture of the object before it, in all its colours, shades, and proportions.* Previous to experience, we could have had no conception that light in passing through such substances, and converging to a point or focus, could have pro duced so admirable an effect. Yet on this circumstance the construction and utility of all our optical instruments depend. The manner in which the rays of light produce this effect may be illustrated by the following figure.

Let L N, Fig. 28, represent a double convex lens, A C *a* its

FIG. 28.



axis, and O B an object perpendicular to it. A ray of light passing from the extremity of the object at O, after being refracted by

shorter the focal distance, the more intense is the heat produced by such instruments. A globular decanter of water makes a powerful burning-glass; and house furniture has been set on fire, by incautiously exposing it to the rays of the sun.

the lens at F, will pass on in the direction E I, and form an image of that part of the object at I. This ray will be the axis of all the rays which fall on the lens from the point O, and I will be the focus where they will be collected. In like manner B C M is the axis of that pencil of rays which proceed from the extremity of the object B, and their focus will be at M, and since all the points in the object between O and B must necessarily have their foci between I and M, a complete picture of the points from which they come will be depicted, and consequently an image of the whole object O B. As the rays cross at C, the centre of the lens, it is obvious that the image of the objects is formed in the focus of the lens in an *inverted position*. This may be illustrated by experiment in the manner stated in page 115.

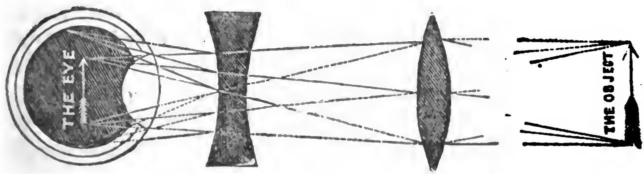
The following are some general principles in relation to images formed by convex lenses.—1. The image subtends the same angle at the centre of the glass as the object itself does.—Were an eye placed at *c*, it would see the object O B and the image I M under the same optical angle, in other words, they would appear equally large.—2. The length of the image is to the length of the object as the distance of the image is to the distance of the object from the lens, that is, M I is to O B : : as C *a* to C A.—3. If the object be at the same distance from the lens as its focus, the image is removed to an infinite distance, in other words, the rays become *parallel*. On this principle light is thrown to a great distance from light-houses, either by a very large convex lens, or by a concave reflector.—4. If the object be at double the distance of the focus from the glass, the image will also be at double the distance of the focus from the glass.—5. All convex lenses magnify the objects seen through them in a greater or less degree. The shorter the focal distance of the lens the greater is the magnifying power. A lens a quarter of an inch focal distance magnifies the diameters of small objects thirty-two times, and their surfaces 1024 times.—The same principles will apply to *concave mirrors*, with this difference, that the images, instead of being formed behind, are formed *before* the mirror.

This property of convex lenses and concave mirrors forming images indicates a very wonderful quality in the nature of light. Previous to experience we could have had no conception that such an effect would be produced; and, in the first instance, we could not possibly have traced it to all its important results and conse-

quences. For any thing we know to the contrary, all the objects of creation might have been illuminated, as they now are, without sending forth either direct or reflected rays, with the property of *forming exact representations of the objects whence they proceeded.* But this we find to be a universal law throughout creation. Not only the rays of the sun, and their reflection from the objects in this lower creation, but the rays which proceed from the most distant stars, are endued with this property, otherwise they could not have been perceived by means of our optical instruments; for, it is by the pictures or images formed in these instruments that such distant objects are brought to view. In every refracting telescope there is an image of the object towards which it is directed formed by the object glass, which image is seen and magnified by the eye-glasses, and without which image no distant object would be perceived by such instruments. In every reflecting telescope, likewise, there is an image or picture of the object formed *before* the principal speculum, in its focus, which image, after being variously modified, is magnified by the eye-glasses of the instruments; and in this manner a correct view is presented of the distant objects towards which the telescope is directed. In like manner, in the compound microscope, it is by means of images formed by the lenses of the instrument that very small objects are represented as enlarged several hundreds of thousands of times, and their minute and wonderful mechanism exhibited to view. The small object glass of the instrument forms a large picture of the minute object, and this picture is again magnified to a great extent by the eye-glasses of the instrument. In the *solar* or *oxy-hydrogen* microscope, it is by means of a small convex glass forming a large image of the object on a white screen, in a darkened apartment, that very minute objects are exhibited of a monstrous size, and the invisible animalcules in fluids displayed in all their surprising shapes and motions.

It appears evident then, that if the Creator had not formed the rays of light with the property of forming images of objects when passing through convex lenses, or reflected from concave mirrors, we could never have constructed telescopes to enable us to view objects at great distances, and consequently, we could never have made those discoveries in the distant regions of the universe which have so greatly enlarged our views of the immensity of creation, and expanded our conceptions of the attributes of the eternal Divinity. We could not have contemplated, as we now can do, the moun-

tains and vales, the hills and caverns, and the diversified aspects of the Moon—the stupendous spots of various kinds which appear on the surface of the Sun—the moons and belts of Jupiter—the wonderful rings of Saturn and his retinue of satellites—nor could



COMMON TELESCOPE.

the exact bulk of such bodies have been ascertained. We should have remained entirely ignorant of the wonderful phenomena of double and triple stars—suns and systems revolving around suns and systems—and of the motions of stars and starry systems, which are crowded into the vast profundities of the Milky Way, and other regions of the heavens—all which objects have a tendency to elevate our conceptions of "The King Eternal, Immortal, and Invisible," and of the vast amplitude of that Empire over which he eternally presides, which now appears to be boundless as the infinity of its Creator.

In like manner, without the property of the rays of light to which we have adverted, we should have wanted the use of the microscope, and been ignorant of the wonderful scenes which it has disclosed in the minute parts of creation. We should have known nothing of those numerous tribes of living beings, invisible to the naked eye, which are found in water, paste, vinegar, and other fluids, and throughout most of the departments of nature. We could have formed no conception that animated beings could possibly exist of a size so small that a million of them would scarcely equal a grain of sand, and yet each of these animalcules furnished with a heart, blood-vessels, instruments of motion, and every other part and function requisite for animal life. We should have been apt to doubt whether even Divine power and intelligence could have formed living beings so minute, and furnished them with all the functions and instruments of life and motion. No human testi-

mony would have been sufficient to have convinced us of the existence of such minute living creatures, unless their existence and faculties had been proved by *ocular demonstration.*—Without this instrument we should never have beheld the purple tide of life and the globules of the blood rushing with rapidity through veins and arteries smaller than the finest hair. We should never have conceived that even the atmosphere is replenished with invisible animation—that the waters abound with myriads of living beings beyond the reach of the unassisted eye—that the whole earth throughout all its departments is full of life—that the texture and arrangement of every vegetable presents a scene of divine mechanism, which would not otherwise have been detected—that the branch of a plant, not half an inch in diameter, contains several hundreds of thousands of tubes, beautifully arranged, for the conveyance of nourishment to the plant—that the fibre of a peacock's feather, not one fourth of an inch in length, displays as much mechanism and beauty as the whole feather to the naked eye—in short, that there are more beauties and exquisite pieces of mechanism in the parts of plants and animals, invisible to the unassisted eye, than are to be seen in all the larger departments of nature connected with our globe.

In these and similar instances we perceive the wonderful and diversified effects which may be produced by a single principle in nature, namely, the power which the rays of light possess in depicting the *images* of objects when passing through convex transparent substances, or reflected from concave specula. We here likewise perceive the attributes of the Almighty exhibited in a new light, which we could not otherwise have known or appreciated. When we contemplate the great universe, and consider that Almighty Power brought it into existence, we can conceive it extending towards infinity, by adding distance to distance, and magnitude to magnitude; but without the microscope we should never have conceived that a region exists invisible to the naked eye, beginning at a visible point, and descending *downwards* towards infinity, containing a world in which numerous tribes of living beings of various forms pass their existence and enjoy a happiness suited to their natures. Nor could we have surmised that the formation of such beings was within the range of Divine wisdom and intelligence. Had we been previously told that such beings might exist, we should most probably have pronounced it

an impossibility. So that through the instrumentality of the microscope, we have become acquainted with a perfection of the Deity, of which we should otherwise have been ignorant; and this leads us to conclude that there are perfections in the Divine Mind which are not yet displayed to finite intelligences, and which will be gradually unfolding throughout the ages of eternity. Hence, we may also conclude, that the Creator intends that his works should be minutely explored by his intelligent offspring, and that all the means within our reach should be employed for this purpose; and hence we have reason to believe that, in the progress of scientific invention and discovery, more expansive views may be opened of Divine power and intelligence, and of the *Arcana* of the Divinity.

On the principles demonstrated by this science, the Stereoscope, the Camera Obscura, the Magic Lantern, the Phantasmagoria, the Kaleidoscope, the Heliostata, the Micrometer—Spectacles, Opera Glasses, Prisms, single, compound, lucernal, and solar Microscopes, reflecting and refracting Telescopes, and other optical instruments, have been constructed, by means of which the natural powers of human vision have been wonderfully encreased, and our prospects into the works of God extended far beyond what former ages could have conceived.

I cannot close this section of my work without saying a word or two on one of the optical instruments mentioned above; viz.,—the Stereoscope. The theory of what is called Binocular vision, or seeing with two eyes, has been demonstrated by means of this instrument. I have already explained the organs of vision; but I omitted to state, that in looking at an object, each eye sees its own side of it; while, if we place ourselves full before the object of sight, we not only see its full front, but also its both sides. Upon the retina of the right eye has been formed the image of the front and right side; and upon the retina of the left eye, the image of the left side and front. Two impressions are thus made upon the optic nerve, and the brain becomes conscious of solidity and form. By the single action of either eye, the brain would receive the impression of but one picture, and the idea of solidity would be mainly dependent upon the light and shadow of the object, assisted by the experience derived from the capability of conveying impression by handling—a faculty possessed by blind persons in great perfection. Indeed, it is probable that a person with only

one eye, and quite unacquainted with that experience, would not be able to appreciate solidity, and that all he saw would appear flat to his sight, varying only in shape, colour, and illumination.

Professor Wheatstone, the projector of the Electric Telegraph, deduced from these considerations the fact, that two pictures of a solid object—say a cube—might be so placed, that, each eye viewing its own side of it at the same moment, the brain would be impressed by the pictures in the same way as if the eye were directed to the object itself, and that, therefore, the same conception of solidity would result.

Experiment proved the truth of this deduction. He contrived an arrangement for holding the two pictures on the opposite ends of a board, face to face, about eighteen inches apart, and then fixed, midway between them, two mirrors placed to each other at an angle of ninety degrees, and consequently the face of each at an angle of forty-five degrees with the picture. On applying his eyes to the apex of the angular mirrors, he was enabled to see the two pictures at the same moment, and by the law of optics, that an object always appears to be seen in the direction of the ray of light that last reaches the eye, he saw directly before him *one* representation only, and *that* having all the appearance of a solid body, and standing out from the paper in a marvellously distinct manner.

This was the first Stereoscope, since known as the Reflecting Stereoscope; it is now used for viewing large pictures. The well known instrument, invented by Sir David Brewster, is called the Refracting or Lenticular Stereoscope; and aided by pictures produced by the beautiful art of Photography, we are now able to examine pictures of various objects—landscapes, building, statuary, and even representations of the human form, with astonishing clearness and fidelity. The *two* pictures are placed side by side in the Stereoscope, the eyes are applied to the sight holes, and a *single* picture standing out, as if solid, from the background, is the wonderful result. Stereoscopes and objects for experiment may now be obtained for a few shillings, and very pretty philosophical toys they are. To recapitulate: in using the Stereoscope both eyes are brought into action, and as the pictures viewed consist of the right eye view, and the left eye view, the brain is impressed precisely as it would have been had the eyes been directed to the real object; and consequently every feature of the one pic

ture as it appears to the senses seems to possess solidity, rotundity, squareness, etc., with a minuteness of detail and beauty truly astonishing.

The Daguerreotype.

Connected with the science of Optics, it may be proper to notice a late discovery for fixing the images formed by convex lenses, distinguished by the name of the DAGUERREOTYPE. Almost every one knows the effects produced by the *Camera Obscura*. A convex glass placed in an opening in a window shutter in a dark room, or in a box constructed for the purpose, forms, on a white screen, placed at its focal distance, a beautiful picture of all the objects which are opposite to it, in their exact proportions, symmetry, and colours. But this picture vanishes the moment the lens or screen is removed. The Daguerreotype is an art by which this picture

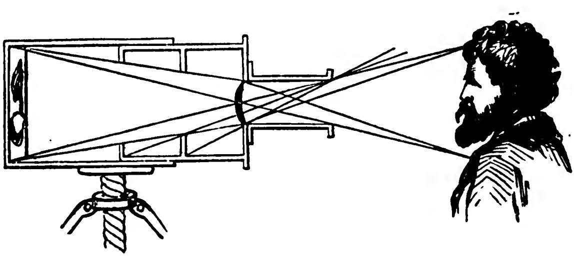


FIGURE SHOWING THE CAMERA, LENS, AND OBJECT, SO AS TO EXPLAIN THE THEORY OF THE DAGUERREOTYPE.

or image may be rendered permanent. It derives its name from M. Daguerre, a member of the French Academy of Fine Arts, who was in partnership with M. Nieper, who, as early as 1814, had commenced researches on this subject; but Daguerre had given up the idea of being able to bring his methods to perfection, till about the year 1838, when the effects produced by his art began to excite a considerable degree of attention; and as a reward for disclosing the process and publishing it to the world, the French government bestowed on the inventor and his partner an annuity of ten thousand francs: (£416 13s. 4d.) M. Arago, when alluding to

this discovery, has the following remark:—"No person has ever witnessed the neatness of outline, precision of form, the truth of colouring, and the sweet gradations of tint, displayed by the Camera, without regretting that an imagery so exquisite and so faithful to nature could not be made to fix itself permanently on the tablet of the machine—who has not put up his aspiration that some means might be discovered by which to give reality to shadows so lovely! Yet, in the estimation of all, such a wish seemed destined to take its place among other dreams of beautiful things—among the glorious but impracticable conceptions in which men of science and ardent temperament have sometimes indulged. *This dream*, notwithstanding, *has just been realized.*"

Our limits will not permit to give a detail of the process by which the effect now stated is produced. We will just state the following general outline.—The designs taken by the Daguerreotype are executed upon thin plates of silver plated on copper. The silver must be of the purest kind, and the thickness of both metals not to exceed that of a stout card. Before placing it in the Camera the following operations are requisite: 1. The plate must be cleansed and highly polished and subjected to a strong heat. 2. The plate has to receive a coating of Iodine. To accomplish this the plate is fixed upon a board, and then put into a box containing a little dish with iodine divided into small pieces, and allowed to remain till it is covered with a *gold coloured* coating, which process must be conducted in a darkened apartment. 3. The Camera is next placed in the front of the landscape or object, and as soon as the focus is adjusted, the light is excluded, and the plate put in, when, in the course of a few minutes, and in some cases in a few seconds, a perfect picture or design is obtained. 4. The plate is next placed over the vapour of mercury to bring out the image, which is not visible when withdrawn from the Camera. In a few minutes it appears. 5. The coating on which the design is impressed is to be removed, in order to preserve it from being decomposed by the rays of light. To do this, the plate is placed in a trough containing common water, plunging and withdrawing it immediately, and then plunging it into a solution of salt and water till the yellow coating has disappeared.

Such is a very abridged sketch of the photogenic operations of M. Daguerre. When finished in a perfect way, the designs thus taken on the plate are exceedingly beautiful and correct, and will

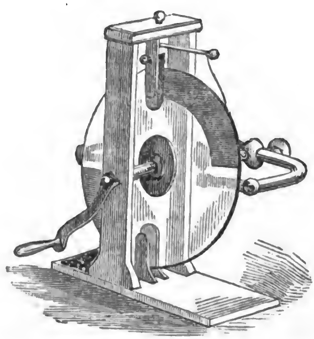
bear to be inspected with a considerable magnifying power, so that the most minute portions of the objects delineated may be perceived; and it has been discovered that an etching of the design can be taken in the common way, and from that again any number of electrotype copies can be produced. Various improvements on the original invention of Daguorre have lately taken place, and portraits are now taken on glass and paper as well as on the silvered plates. These processes are known indifferently, as the collodion, calotype, talbotype, paper, and glass processes, while the art is known as photography, and its results as photographs or sun pictures. As the principle in all these branches of the art is identically the same, it is needless to trouble the reader with the various details and modifications recently introduced.

This invention may be considered as still in its infancy; but in the course of its improvement, its results may be highly beneficial and extensive. To use the words of Arago: "To copy the millions of millions of hieroglyphics which entirely cover to the very exterior of the great monuments at Thebes, Memphis, Carnac, etc., would require scores of years and legions of artists. With the Dauguerreotype a single man would suffice to bring to a conclusion this vast labour; and at the same time, such designs should incomparably surpass in fidelity, in truth of local colour, the works of the ablest artists." It is probable, too, that this art may be applied to taking exact pictures of the heavenly bodies—not only of the sun, but even of the moon, the planets, and the stars. The plated disks prepared by Daguerre receive impressions from the action of the lunar rays to such an extent as permits the hope that photographic charts of the moon may soon be obtained. Nor is it perhaps too much to expect that the rays of the stars —even of distant nebulæ may thus be fixed, and a delineation of their objects produced which shall be capable of being magnified by powerful microscopes.—This invention leads us to conclude that we have not discovered all the wonderful properties of that LIGHT which unveils to us the beauties and sublimities of the universe; and that thousands of admirable agencies and objects hitherto unknown may soon be disclosed to our view through this medium, as we advance in our researches and discoveries.[1]

[1] For a more particular detail of the principles and experiments connected with optics, and the construction of all kinds of telescopes, the reader is referred to the Author's work entitled 'The Practical Astronomer.'

Electricity.

This name has been given to a science which explains and illustrates the operations of a very subtile fluid, called the *electric fluid,* which appears to pervade every part of nature, and to be one of the chief agents employed in producing many of the phenomena of the material world. If a piece of amber, sealing-wax, or sulphur, be rubbed with a piece of flannel, it will acquire the power of attracting small bits of paper, feathers, or other light substances. If a tube of glass, two or three feet in length, and an inch or two in diameter, be rubbed pretty hard, in a dark room, with a piece of dry woollen cloth, besides attracting light substances, it will emit flashes of fire, attended with a crackling noise. This luminous matter is called electricity or the *electric fluid.* If a large globe, or cylinder of glass, be made to revolve rapidly and in its passage rub against a cushion, streams and large sparks of bluish flame will be elicited, which will fly round the glass, attract light bodies, and produce a pungent sensation, if the hand be held to it. This glass, with all its requisite apparatus, is called an *electrical machine.* It is found that this fluid will pass along some bodies and not along others. The bodies over which it passes freely are water, and most other fluids, except oil and the aërial fluids; iron, copper, lead, and in general all the metals, semi-metals, and metallic ores; which are therefore called *conductors* of electricity. But it will not pass over glass, resin, wax, sulphur, silk, baked woods, or dry woollen substances; nor through air, except by



AN ELECTRICAL MACHINE.

AN ELECTRIC SPARK.

force, *in sparks,* to short distances. These bodies are therefore called *non-conductors.*

The following facts, among others, have been ascertained respecting this wonderful agent:—That all bodies with which we are acquainted possess a greater or less share of this fluid—that the quantity usually belonging to any body produces no sensible effects; but when any surface becomes possessed of *more* or *less* than its natural share, it exhibits certain appearances in the form of light, sound, attraction, or repulsion, which are ascribed to the power called *electric*—that there are two different species of the electrical fluid, or at least two different modifications of the same general principle, termed *positive* and *negative* electricity—that positive and negative electricity always accompany each other; for if a substance acquire the one, the body with which it is rubbed acquires the other—that it moves with amazing rapidity, having been transmitted through wires of several miles in length, without taking up any sensible space of time; and therefore it is not improbable, that were an insulated conducting substance extended from one continent to another, it might be made to fly to the remotest regions of the earth, in a few seconds of time[1]—that it has a power of suddenly contracting the muscles of animals, or of giving a *shock* to the animal frame—that this shock may be communicated, at the same instant, to a hundred persons, or to any indefinite number who form a circle, by joining hands—that it may be accumulated to such a degree as to kill the largest animals—that vivid sparks of this fluid, attended with a crackling noise, may be drawn from different parts of the human body, when the person is *insulated,* or stands upon a stool supported by glass feet—that electricity sets fire to gunpowder, spirits of wine, and other inflammable substances—that it melts iron wire and destroys the polarity of the magnetic needle—that it augments the natural evaporation of fluids, promotes the vegetation of plants, and encreases the insensible perspiration of animals; and can be drawn from the clouds by means of electrical kites, and other elevated conductors. By means of the electricity, small models of machinery have been set in action; orreries to represent the movements of the planets have been put in motion; and small bells have been set a-ringing for a length of time; and, in consequence of the knowledge we have acquired of the mode of its operation in

[1] See Chap. III, Art. Electric Telegraph.

the system of nature, the lightnings of heaven have been arrested in their course, and constrained to descend to the earth, without producing any injurious effects.

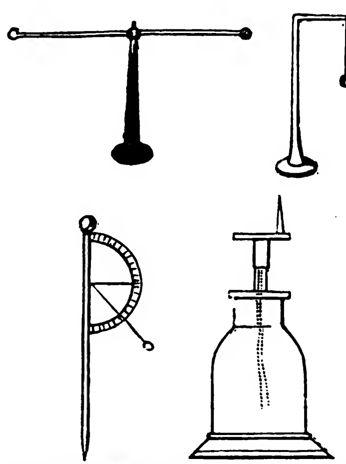
From these, and a variety of other facts and experiments, it is now fully ascertained, that *lightning* and *electricity* are identical; and that it is the prime agent in producing the awful phenomena of a thunder-storm; the lightning being the rapid motion of vast masses of electric matter, and *thunder* the *noise*, with its echoes, produced by the rapid motion of the lightning through the atmosphere, and therefore it may not be inexpedient to offer a few remarks on *Atmospherical Electricity*, and on the phenomena of *Thunder-storms.*

The electricity of the atmosphere is found to be subject to many variations, depending on the situation of places, the seasons of the year, the phenomena of the clouds, and many other circumstances. It is generally strongest in elevated and insulated situations, as on the tops of hills, mountains, and high buildings: It is not to be observed in streets, in houses, under trees, or in any enclosed places, though it is sometimes found to be pretty strong on quays and bridges. It is likewise not so much the absolute *height* of places as their situation that produces this effect; for example, a projecting angle of a high hill will frequently exhibit a stronger electricity than the plain at the top of the hill, as there are fewer points in the former to deprive the air of its electricity.—The state of the air in which the electricity is strongest is *foggy weather.* This is always accompanied with electricity, except when the fog is going to resolve into air.—Strong winds diminish its intensity: they mix together the different strata of the atmosphere, and make them pass successively towards the ground, and thus distribute the electricity uniformly between the earth and the air.—The electricity of serene weather is much weaker in summer than in winter. In general, in summer, when the ground has been dry for some days, and the air is also dry, the electricity generally encreases from the rising of the sun till three or four in the afternoon, when it is strongest; it then diminishes till the dew begins to fall, which again reanimates it, though after this it declines, and is almost extinguished during the night.—In winter and in serene weather the electricity is generally weakest in the evening, when the dew has fallen, till the moment of sunrising; its intensity afterwards augments by degrees, sometimes sooner, and sometimes later; but

generally before noon it attains a certain maximum, from which it again declines till the fall of the dew.

It appears, therefore, that atmospherical electricity, like the sea, is subject to *a flux* and *reflux*, which causes it to encrease and diminish twice in twenty-four hours. The moments of its greatest force are *four hours after the rising and setting of the sun;* those when it is weakest *precede the rising and setting* of the solar orb.

The electricity of the air is invariably positive in serene weather, both in summer and winter, day and night, in the sun or in the dew. It would seem, therefore, that the electricity of the air is essentially positive, and that whenever it appears to be negative, in certain rains or in storms, it probably arises from some clouds which have been exposed to the pressure of the electric fluid contained in the upper part of the atmosphere, or to move elevated clouds that have discharged a part of their fluid upon the earth or upon other clouds.—The above and other facts respecting the electricity of the atmosphere have been deduced from observations made with the *Electrometer* and other electrical instruments.

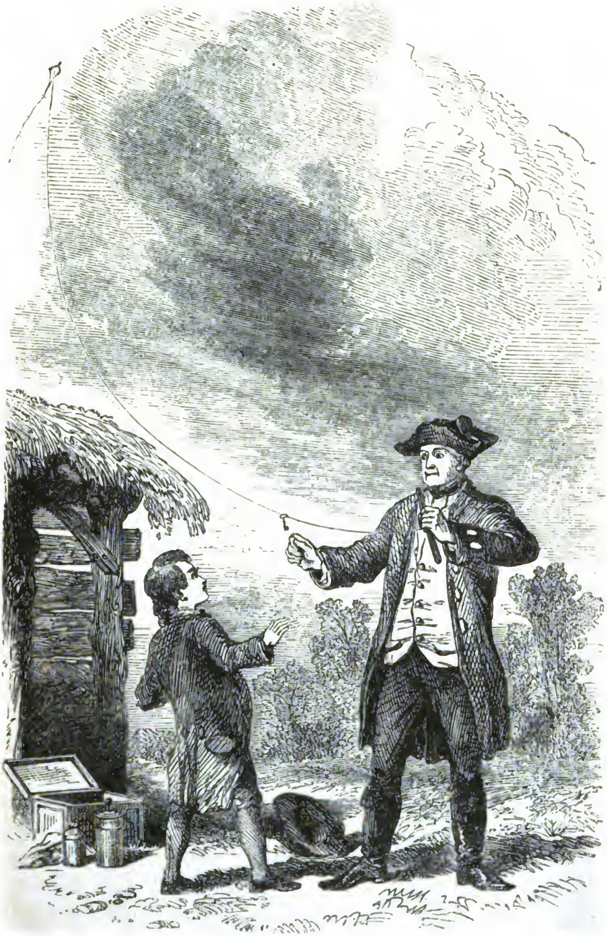

ELECTROMETERS AND ELECTROSCOPE.

The following positions have been deduced from many observations made on the electrical state of the atmosphere:—1. That in the spring, when the plants begin to grow, temporary electrical clouds begin to appear and pour forth electric rain. 2. That the electricity of the clouds and of the rain increases till that part of autumn when the last fruits are gathered. It is hence supposed to actuate and animate vegetation, and to give to rain that power which renders it more propitious to vegetables than any other

kind of watering. Hence the practice of watering trees and other vegetables with water impregnated with the electrical fluid.

Soon after the attention of philosophers was directed to the subject of electricity, and when the effects produced by the electrical phial were observed, it began to be strongly suspected that lightning and the electrical fluid were identical, and that electricity was the principal cause which operated in producing the phenomena of a thunder-storm. The following circumstances tended to confirm this opinion:—1. The colour and crooked form of zig-zag lightning appeared to be similar to that of a vivid electric spark between distant bodies, and unlike every other appearance of light. 2. Lightning affected to take the best conductors of electricity, such as bell-wires, which were frequently melted and destroyed by it; also the tinfoil on the backs of mirrors, and the gilding of screens and leather hangings. 3. Lightning, like electricity, was observed to strike the most elevated objects, as hills, trees, steeples, and other prominent and elevated objects. 4. Lightning was found to burn, explode, and destroy conducting substances precisely as electricity does. It dissolves metals, melts wires, and explodes and tears to pieces bodies which contain moisture. 5. It has sometimes struck a person blind; and electricity has done the same to a chicken, which it did not kill. 6. It affects the nervous system in a way resembling some of the known effects of electricity. 7. Both lightning and electricity are well known to destroy and to change the polarity of the mariner's needle. 8. Lightning kills, and the appearances perfectly resemble those of a mortal stroke of electricity. The muscles of the body struck are all in a state of perfect relaxation.

Notwithstanding these striking resemblances, it was some time before the identity of lightning and electricity was determined by actual experiment. Dr. Franklin of Philadelphia was the first philosopher who proposed the manner in which this might be accomplished, namely, by erecting a tall mast or pole on the highest part of a building, and furnishing the top of it with a metallic point, properly insulated, with a wire leading to an insulated apparatus for exhibiting the common electrical experiments. In the meantime, Franklin—while waiting for the erection of a spire in Philadelphia for this purpose, impatient of delay, contrived another ingenious method of presenting a point to a thunder cloud, at a very great distance from the ground. This was by fixing his



FRANKLIN DISCOVERING ELECTRICITY.

point on the head of a paper kite which the wind was to raise to the clouds, while the wet string that held it should serve for a conductor of the electricity. Preparing therefore a large silk handkerchief and two cross sticks of a proper length, on which to extend it, he took the opportunity of the first approaching thunder-storm to walk into a field in which there was a shed convenient for his purpose. But, dreading the ridicule which too commonly attends unsuccessful attempts in science, he communicated his intended experiment to no one but his son, who assisted him in raising the kite. The kite being raised—the end of a string being tied to a silk string which he held in his hand—and a small key being fastened at the place of junction, a considerable time elapsed before there was any appearance of its being electrified. One very promising cloud had passed over it without any effect; when, at length, just as he was beginning to despair of his contrivance, he observed some loose threads of the hempen string to stand erect, and to avoid one another, just as if they had been suspended on a common conductor. Struck with this promising appearance, he immediately presented his knuckle to the key, and we may easily judge of the exquisite pleasure he felt at the moment the discovery was complete. He perceived a very evident electric spark. Others succeeded even before the string was wet, so as to put the matter past all dispute; and when the rain had wetted the string, he collected the electricity very copiously.

Franklin related to a person that, when he saw the fibres of the cord raise themselves up like hog's bristles, he uttered a deep sigh, and would have wished that moment of joy to have been his last; and he returned to his house in a state of perfect happiness, now feeling that his name was never to die.—This experiment was performed in the month of June, 1752—a month after the electricians in France had verified the same theory in the way which Dr. Franklin had originally suggested, but before he had heard of any thing they had done. This experiment was performed by M. Dalibard, at Marly la Ville, about six leagues from Paris. It consisted of a bar of the length of forty feet, and it was electrified on the 10th of May, 1752, for the space of half an hour, during which time the longest sparks it emitted measured about two inches.

We may justly consider the above as one of the greatest of philosophical discoveries, and as doing the highest honour to the inventor; for it was not a suggestion from an accidental observa-

tion, or a mere conjecture, but it arose from a scientific comparison of facts, and a sagacious application of the doctrine of positive and negative electricity—a doctrine wholly Dr. Franklin's, and the result of the most acute and discriminating observation.—The grand practical use which he made of this discovery was to secure buildings from being damaged by lightning—a thing of vast consequence in all parts of the world, but more especially in several parts of America, where thunder-storms are more frequent, and their effects more dreadful than they are ever known in our climate. This important end is accomplished by fixing a pointed metallic rod higher than any part of the building, and communicating with the ground or rather with the nearest water. This wire the lightning is sure to seize upon in preference to any other part of the building—by which means this dangerous power is safely conducted to the earth, and dissipated without doing any injury to the building or its inhabitants.

The phenomena of thunder and lightning have been regarded, both by the savage and the civilized tribes of men, with emotions of awe mingled with apprehension and dread. Of all the atmospherical phenomena there are none more grand or terrific. Could we contemplate the scene presented on such an occasion without any emotion of alarm, it would yield a source of sublime enjoyment to a contemplative mind. The silence and calm which generally prevail at the beginning of a storm—the sable aspect of the heavens—the solemn gloom produced by the gradual approach of the charged clouds—the lightning flashing from cloud to cloud, descending to the earth in sheets of flame, or whirling like fireballs through the air—the deluge of rain—the rattling of hail—and the deep, prolonged, and aggravated roar of the thunder, form a scene truly grand and sublime. To view from an eminence, under a canopy, the progress of the storm, to mark the various directions and coruscations of the lightning, the successive illuminations of the sky and the distant hills, the agitation of the clouds, and the incessant reverberations of the thunder-claps, *with perfect tranquillity and conscious security,* would be a feast to a poetic imagination, and would highly gratify a philosophic enquirer. It would produce emotions, similar to those we feel when viewing from a deep dell the dashing of a mighty cataract with all the rugged and romantic scenery around and above us; or those we experience when, from a safe situation on land,

we behold the ocean raging in all its fury, and dashing to pieces the mariner's bark.

Very different, however, are the emotions generally excited on the appearance of a thunder-storm. Many are so alarmed at the thought of such storms, that they can scarcely pronounce the words *thunder* and *lightning* without trembling, and are seized with a tremor as soon as a stormy cloud appears above the horizon. They complain that, at a season when all nature presents the most pleasing scenes, and invites to cheerfulness, their joy is so much disturbed by those dire phenomena, and that they are the only circumstances which interrupt the delightful enjoyments of the summer months. Even the philosopher who is raised above vulgar fears, and is better acquainted with the nature and the causes of those phenomena, cannot at all times contemplate them with perfect tranquillity, as in certain cases he cannot be sure that he is completely beyond the range of their destructive influence. When he considers that an electric stroke proceeding from a surface of only a few square yards in extent will be sufficient to kill a strong animal, he cannot but be struck at the idea of the effects which may be produced by a shock ten thousand times stronger, proceeding from a cloud several miles in extent; and therefore, however much he may wish to perform electrical experiments during a storm, experience teaches us that, even where every precaution is attended to, they cannot be performed without danger,—nor can any one contemplate the phenomena of a violent thunder-storm without certain feelings of apprehension and awe.

A thunder-storm usually happens in calm and sultry weather. A low, dense, and dark cloud begins to be formed in a place previously clear; it increases rapidly in size and apparent density, and attracts to it other clouds in its neighbourhood. Its upper surface appears of an arched form like great bags of cotton, while its lower surface is commonly level as if it rested on a glass plane. Soon after appear numberless small rugged clouds, like flakes of cotton. These move about in all directions, and are continually changing their ragged shape. During this confused motion, the whole mass of small clouds approaches the great one above it, and, when near it, the clouds of the lower mass frequently coalesce with each other, before they finally coalesce with the upper cloud— The heavens now begin to darken apace, the whole mass sinks

down; wind arises, and frequently shifts in squalls; small clouds are seen moving swiftly in various directions, and the lightning now darts from cloud to cloud, and from one part of the cloud to another, so as to illuminate the whole mass. When the cloud has acquired a sufficient extent, the lightning strikes the earth in two opposite places, the path of the lightning lying through the whole body of the cloud and its branches. A continuation of these discharges of electric matter rarifies the cloud, and in time it dissipates. This is accompanied with heavy rain, and sometimes with hail showers; and then the upper part of the clouds becomes high and thin.

During thunder-storms the lightning frequently assumes different forms, and is sometimes very terrific. The most formidable and destructive form which lightning is ever known to assume is that of *balls of fire*. The motion of these is often perceptible to the eye; but wherever they fall, much mischief is occasioned by their bursting, which they always do with a sudden explosion like that of a musket, or cannon. Sometimes they quietly run along, or rest for a little upon anything, and then break into several pieces, each of which will explode, or the whole ball will burst at once, and produce its mischievous effects only in one place. By the action of these balls, houses, corn-yards, and other combustible materials have been set on fire and consumed, and when cattle or human beings have been in their course, they have been instantly killed. Next to this kind of lightning in its destructive effects is that of the *zig-zag* kind, which most frequently accompanies a thunder-storm. Sometimes this species of lightning makes only one angle like the letter V, sometimes it has several branches, and sometimes it appears like the arc of a circle. The third species of lightning is generally known by the name of *sheet* lightning. This kind of lightning has a kind of indistinct appearance, without any determinate form, like the sudden illumination of the atmosphere, occasioned by firing a quantity of loose gunpowder. It is sometimes seen in a serene sky, and is seldom or never known to do any injury. It has also been remarked that the *colour* of the lightning indicates in some measure its power to do mischief; the palest and brightest flashes being most destructive, while such as are red, or of a darker colour, are found to do less mischief.

The general scene of a thunder-storm is the heavens, or the superior regions of the atmosphere; and it is by no means a fre-

quent case that a discharge is made into the earth. The electric fluid discharges itself from one cloud to another, and when the clouds are high in the air there is little danger to objects on the surface of the earth. It is only or chiefly when the thunder cloud comes within the striking distance of the earth, and the lightning strikes perpendicularly downwards that the danger is to be apprehended. When the flashes appear parallel the scene of the storm is in the clouds, but when they appear to dart perpendicularly the thunder cloud has descended so low as to be within the striking distance, and all the objects in its neighbourhood are within the limits of danger. The interval of time between seeing the flash and hearing the report of the thunder is generally about seven or eight seconds, which, reckoning sound to move at the rate of 1142 feet per second, shows that the thunder cloud is nearly two miles distant. But should the sound be heard within a second or two of seeing the flash, we may conclude that the cloud is discharging its electricity into the earth, at no great distance, and consequently that we are in the neighbourhood of danger, in which case numerous accidents have happened both to buildings, cattle, sheep, and human beings.

It has been supposed that it is possible for a man or an animal, situated far from the place where the lightning flashes, to be nevertheless exposed to great danger or even to the loss of life in consequence of the explosion. Earl Stanhope, in his treatise on electricity, attempts an explanation of this singular effect, upon the re-establishment of the equilibrium of the electrical state of the earth and air, to which he has given the name of the *returning stroke*,—that is, that the earth may discharge lightning into the atmosphere at a considerable distance from the electrical cloud. An accident, which happened near Coldstream on the Tweed, on the 19th July, 1785, is supposed to be corroborative of this opinion. Between twelve and one, on that day, a storm of thunder and lightning came on. This storm, as described by Mr. Brydone, was at a considerable distance from his house, the intervals between the flash and report being from twenty-five to thirty seconds, so that the place of explosion must have been five or six miles distant. While observing the progress of the storm, he was suddenly surprised with a loud report, neither preceded nor accompanied by any flash of lightning, which resembled the explosion of a great number of muskets, in such quick succession that the ear

could scarcely discriminate the sound. On this the thunder and lightning instantly ceased, and the sky recovered its serenity. In a little time Mr. Brydone was informed that a man with two horses had been killed by the thunder, in the immediate neighbourhood, and on running to the place he found the two horses lying on the spot. The skin of the man who was killed was much burned and shrivelled on the right thigh, with many marks of the same kind all over the body, and his clothes, particularly his shirt, had a strong smell of burning; and there was a zig-zag line, above an inch broad, extending from the chin to the right thigh, and which seemed to have followed the direction of the buttons of his waistcoat. The cart he was in was loaded with coals, and he was sitting on the fore part of it. The horses, which were killed, had their hair singed over the greater part of their bodies. The left shaft of the cart was broken, and splinters thrown off particularly where the timber of the cart was connected by nails or cramps of iron. About four-and-a-half feet behind each wheel, there was a circular hole twenty inches in diameter, the centre of which was exactly in the centre of each wheel. The earth was torn up as if by violent blows of a pick axe, and small stones scattered all around; and there were evident marks of fusion on the iron rings of the wheels. About the same time a shepherd, tending his flock in the neighbourhood, observed a lamb drop down, which was found quite dead, at the same time he felt as if fire had passed over his face, though the lightning and claps of thunder were at a considerable distance. A woman, making hay near the banks of the river, fell suddenly to the ground, and called out that she had received a violent blow on the foot, and could not imagine whence it came; and the Rev. Mr. Bell, when walking in his garden a little before the accident, felt several times a tremor in the ground.

The conclusion drawn from these facts is, that at the time of the explosion, the equilibrium between the earth and the atmosphere was completely restored, as no more thunder was heard nor lightning observed; the clouds were dispelled, and the atmosphere resumed the most perfect tranquillity. From the facts above stated, the following among other conclusions have been drawn:—1. That the man and horse were not killed by any *direct main-stroke, or explosion* from a thunder cloud either positively or negatively electrified. 2. They were not killed by any *transmitted*

mainstroke either positive or negative. 3. The mischief was not done by any *lateral explosion*. 4. That electrical fire did pass from the earth to the cart, through that part of the iron of the wheels which was in contact with the ground, or, in other words, by what is called the returning stroke; and consequently that persons may be injured and even killed, at a considerable distance from the immediate scene of a thunder-storm,—a circumstance which, I presume, does not frequently happen.

Thunder-storms are more frequent and terrific in the region of the Torrid Zone than in our temperate climate. In the East Indies and the countries adjacent, the approach of the Monsoons is attended with such a thunder-storm as can scarcely be imagined by those who have only seen that phenomenon in a temperate climate. It generally begins with violent blasts of wind, which are succeeded by floods of rain. For some hours lightning is seen almost without intermission; sometimes it only illuminates the sky, and shows the clouds near the horizon; at other times, it discovers the distant hills, and again leaves all in darkness; when, in an instant, it re-appears in vivid and successive flashes, and exhibits the nearest objects in all the brightness of day. During all this time the distant thunder never ceases to roll, and is only silenced by some nearer peal, which bursts on the ear with such a sudden and tremendous crash as can scarcely fail to strike the most insensible heart with awe and terror. At length the thunder ceases, and nothing is heard but the continual pouring of the rain, and the rushing of the rising streams. After a night of this description the morning presents a most gloomy spectacle,—the rain still descending in torrents, and scarcely allowing a view of the blackened fields disrobed of their beauties.

Even in our own temperate clime thunder-storms are sometimes violent and terrific, and attended with many destructive effects. Buildings shattered and demolished—trees rent and torn asunder—the hardest metals in a moment dissolved—stones and rocks rent and broken—stacks of corn set on fire—men and other animals knocked down, struck blind, or instantaneously killed—are some of the terrible effects of that powerful fluid which darts through the atmosphere during a storm. Every returning year is generally marked with some affecting instances of this kind in one part of the country or another, and frequently in different districts at the same time. From a register of such accidents which we kept in 1811, it appears, that during the months of June and July that

year, within the bounds of seven counties in England, two large oaks were shattered—a windmill and several other houses struck and the walls and windows shattered and destroyed, 4000 panes of glass broken, two cows and twenty-six sheep killed, besides a great number not particularly specified, *eight* persons were struck down and injured, and *eleven* men struck dead,—the shepherd of Mr. Edman of Marblethorp, who had his skull shattered to pieces and was rendered a shocking spectacle; two men who had taken shelter in a barn near Stone; a lad at Frome who was working at his loom in the ground floor of a house which was struck, several persons who had taken shelter under trees, etc. In Scotland, during the same period four or five persons were killed, a considerable number of persons struck down and materially injured, several buildings damaged, and a considerable number of cattle and sheep were destroyed by the stroke of lightning. During the storms of June, July, and August, 1846, particularly in England, many lives were lost, and immense injury was done to buildings of different descriptions, and vast numbers of horses, cattle, and sheep were destroyed. The public journals specified from twelve to fifteen or more persons killed by the lightning, besides numbers seriously injured. In one field near Wells, seventy-four sheep were struck down and killed by one stroke of lightning. At a toll-house, near Gloucester, fifty-one persons crowded together for shelter, when a flash of forked lightning struck a neighbouring tree, glanced thence into the house in the midst of the affrighted inmates, and exploding with a terrible report, threw them to the ground, and shaking the building to its foundations, knocked out walls, windows, and doors, and covered the stunned people with hundred weights of brick, plaster, door-posts, and fragments of rafters. Most of them were found in a state of insensibility, and two or three supposed to be dead, but were afterwards supposed to be in the way of recovery. The storm which raged on the 1st of August in London and the neighbouring counties was particularly awful and destructive. In the metropolis immense injury was done both to public and private buildings. In Buckingham palace, many thousand squares of glass were demolished, amounting in value to nearly £2000. Somerset House, Burlington Arcade, Baker Street Bazaar, Paddington Terminus of the Great Western Railway, the Horticultural Gardens, Cheswick, the Botanic Gardens at Kew, and in the Regent's Park, the Westminster School of Medicine, the

Houses of Lords and Commons, and a vast number of other public and private buildings, were considerably damaged. At Messrs. Cubitt's factory, Millbank, nearly 14,000 squares of glass were demolished. In most of the surrounding counties, likewise, much damage was sustained—cattle, sheep, and several human beings were destroyed—houses were struck by the electric fluid, and partly destroyed—stacks of corn were set on fire—the incessant peals of thunder and sheets of vivid lightning were followed by torrents of rain and hail, which produced universal inundations, and caused the rivers to overflow their banks, undermining houses, and sweeping away the fruits of harvest. In some places the flashes of lightning were emitted from all parts of the horizon, and encreased in rapidity and vividness till midnight, when the heavens were in one continued glare, and the thunders bursting over head. Such are some of the tremendous effects of thunder-storms which occasionally take place, even in our temperate climate.

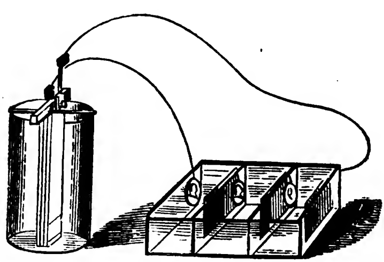
It was formerly supposed that to be near trees or metallic substances during a thunder storm was highly dangerous, but late science has proved these suppositions to be erroneous.

When lightning is transmitted through a chain of animals, either in mutual contact, or connected by conductors,—it is found that the chief if not the only injury is sustained by the first and last individuals of the series. Of this the following instances, among many others, afford sufficient evidence. On the 2nd of August, 1785, a stable at *Rambouillet*, in France, was struck by lightning. A file of thirty-two horses received the fluid; of these, the *first* was laid stiff dead, and the *last* was severely wounded. The intermediate thirty were only thrown down.—On the 22nd of August, 1808, lightning struck a school-room in *Knonau*, in Switzerland. Five children read together on the same bench. The *first* and *last* were struck dead, the other three only received a shock.—At a village in *Franche-Compte*, lightning struck a chain of five horses, killing the first and last only.—At *Praville* near *Chartres*, a miller walked between a horse and a mule loaded with grain. Lightning struck them, killing the horse and mule. The man was unhurt, except that his hat was burned, and his hair singed.

There can be little doubt that, in combination with steam, the gases, and other agents, electricity also produces many of the terrific phenomena of earthquakes, volcanoes, whirlwinds, waterspouts and hurricanes, and the sublime coruscations of the *aurora*

borealis.—In the operations of this powerful fluid, we behold a striking display of the sovereignty and majestic agency of God. In directing its energies, "his way is in the whirlwind and the storm, and the clouds are the dust of his feet; the heavens are covered with sackcloth, the mountains quake before him, the hills melt, the earth is burned at his presence, and rocks are thrown down by him;"[1] It is easy to conceive, that by a few slight modifications produced by the hand of Omnipotence, this powerful fluid might become the agent of producing either the most awful and tremendous, or the most glorious and transporting scenes, over every region of our globe. As it now operates, it is calculated to inspire us rather with awe and terror than with admiration and joy; and to lead our thoughts to a consideration of the state of man as a depraved intelligence, and a rebel against the government of his Maker.

Electricity is rapidly extending its boundaries, and its influence as an important agent in the arts; and, as yet, we can form no adequate conception of the results which may flow from the investigations into its nature, combinations, and applications, which are now making by the scientific world, or of the powerful effects it may produce, when thoroughly wielded by the hand of genius. It has already been applied to many useful purposes—to remove obstructions in the human frame—to cure diseases—to ascertain the depth of the sea—to produce explosions for effecting mechanical operations,—and for conveying intelligence by means of the Electric Telegraph at the rate of 192,000 miles in a second. Among its recent applications is *the process of copying with perfect accuracy engraved copperplates, medals, seals, etc.*—and of gilding, plating, and etching, with great beauty and precision. This art has been denominated ELECTROTYPE, and was discovered by Mr. Thomas Spencer of Liverpool, in 1839. It was also discovered on the Continent by Professor Jacobi. The materials recommended by him for forming the



ELECTROTYPE BATTERY AND TROUGH.

[1] Nahum i, 3—6.

moulds on which impressions are taken are *fusible metal, wax*, and *stearine*. When a copy is taken from any copperplate or medal, any number of copies can be produced equally as good as the first. The process is simple, but our limits will not permit to enter into its details.

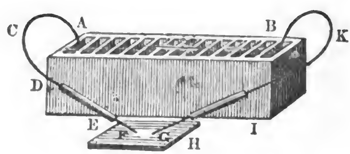
An important combination of the Electrotype with the Daguerreotype process has lately been discovered, which promises to lead to some important results. A Daguerreotype picture can be produced in the ordinary way, as formerly described—it can be etched according to the present process, and from this etching an indefinite number of electrotype copies can be obtained. As an illustration of the perfection attendant on this process, the inventor states that, from a Daguerreotype plate which had on it a sign-board measuring 1-10th by 6-100ths of an inch, five lines of the inscription can be distinctly read by the aid of a microscope applied to the electrotype copy. So that, as the author remarks, 'instead of a plate being inscribed as drawn by Landseer, and engraved by Cousins, it may be said, *drawn by Light, and engraved by Electricity*."

Galvanism.

Galvanism—so called from its discoverer, Galvani—is intimately connected with electricity, though it is generally considered as a branch of Chemistry. It is only another mode of existing electrical action. In electricity the effects are produced chiefly by *mechanical* action; but the effects of Galvanism are produced by the *chemical* action of bodies upon each other. If we take a piece of zinc, and place it under the tongue, and lay a piece of silver, as large as a half-crown, above it; by bringing the outer edges of these pieces into contact, we shall immediately experience a peculiar and disagreeable taste, like that of copper. The same thing may be noticed with a guinea and a piece of charcoal. If a person, in the dark, put a slip of tinfoil upon one of his eyes, and a piece of silver in his mouth, by causing these pieces to communicate, a faint flash will appear before his eyes. If a living frog or a fish, having a slip of tinfoil pasted upon its back, be placed upon a piece of zinc, by forming a communication between the zinc and tinfoil, the spasms of the muscles are excited. These and similar effects are produced by that modification of electricity

which has been termed *Galvanism*. Three different conductors, or what is called a *galvanic circle*, are requisite to produce such effects. A piece of copper, a piece of flannel, moistened with water or acid, and a piece of zinc, laid upon one another, form a circle; and if this circle be repeated a number of times, a galvanic pile or battery may be formed, capable of giving a powerful shock. The most common and convenient form, however, of a battery, is found to be a trough of baked wood, three or four inches deep, and as many wide. In the sides are grooves, opposite to each other, into each of which is placed a double metallic plate of zinc and copper soldered together, and the cells are then filled either with salt and water, or with a solution of nitrous acid and water.

The following figure represents a small trough of this description, where A B represents a galvanic battery, A C D F is a wire which communicates with the last plate of the battery at A; B K I H G is another wire which communicates with the last plate at B; D E H I are two glass tubes through which those wires pass, and into which they are fastened sufficiently steady. These tubes serve for moving the wires; for if the operator applies his finger to the middlemost parts of those tubes, he may move the wires wherever he pleases, without the fear of receiving a shock. If the two extremities F G are brought sufficiently near to each other, the spark will be seen between them. It is between those extremities that the combustible substances, or metallic leaf, etc. are to be fixed in order to be fired or consumed. The figure represents the situation of the wires in the act of inflaming gunpowder. A battery of this description consisting of two hundred pairs of metallic plates, (namely, copper and zinc, each five inches square,) melted twenty-three inches of fine iron wire.



GALVANIC BATTERY.

The most striking effect of the galvanic, or, as it should be called, the *Voltaic* battery—from M. Volta, who made many improvements on Galvani's discovery—is the intense light which is produced by placing two pieces of charcoal, cut into the shape of pointed pencils, at the two ends of the wires of an interrupted circuit. When the battery is a very powerful one, and the charcoal

points are brought within the thirtieth of an inch of each other, a bright spark is produced. By withdrawing the points from each other, a constant discharge takes place through the heated air, in a space of from one to four or more inches, according to the energy of the apparatus, producing a most brilliant arch of light, of considerable breadth, and in the form of a double cone. This light equals the brilliancy of the sun, and cannot be borne by eyes of common strength, unless protected by glasses. That it does not arise from combustion is proved by the fact, that very little of the charcoal is wasted by its continuance for a considerable time. The metals are burned or deflagrated, when applied in the form of very thin leaves. Gold emits a very vivid white light, inclining a little to blue; copper or brass leaf, commonly called Dutch gold, burns with a beautiful green light; the flame of silver is a vivid green, somewhat like that of emerald; and that of zinc, a bluish white flame, fringed with red.—One of the most important chemical effects of Galvanism is that of producing *decomposition*. The substance first decomposed by it was *water*. When two gold or platina wires are connected with the opposite poles of a battery, and their free extremities are plunged into the same cup of water, but without touching each other, hydrogen gas is disengaged at the negative wire, and oxygen at the positive side. By collecting the gasses in separate tubes as they are formed, they are found to be quite pure, and in the exact proportion of two measures of hydrogen to one of oxygen. If wires of a more oxidable metal, such as iron, be employed, the hydrogen gas will appear as usual, but the oxygen, instead of escaping, combines with the metal, converting it into an oxide.

Numerous other compounds, such as acids and salts, are found to be decomposable in the same manner, one of these elements appearing at one side of the battery, and the other at the opposite extremity.—The following is an interesting experiment in relation to the decomposition of saline substances. Let two cups of agate or gold—as glass is liable to be acted upon—be connected with a few fibres of amianthus moistened with water, and a solution of sulphate of soda or potash, nitrate of potash, nitrate of silver, or any other compound salt, be placed in each of the cups:—If we introduce into one the positive wire, and into the other the negative wire of a galvanic battery, in action for a short time, the principles of the salt will be separated, and all the acid will be

collected in the vessel with which the positive pole communicates, and all the base in the other, each being conveyed by the medium of the moistened, and, as it would appear, in opposite currents passing one another in so narrow a space, without combining or otherwise interfering with each other's movements. Again, if the saline solution be placed in one of the cups and distilled water in the other, and the positive wire inserted in the latter, the acid will leave both the base with which it was united and the vessel in which it was, and pass by the amianthus wholly into the water, the base remaining in the first cup.

What is still more extraordinary, the elements of compound bodies are actually conveyed, by the influence of the electric current, *through solutions of substances*, on which, under other circumstances, they would have exerted an immediate and powerful chemical action, without any such effect being produced. Acids, for example, may be transmitted from one cup, connected with the negative pole, to another cup on the opposite or positive, *through a portion of a fluid in an intermediate cup* tinged with any of the vegetable coloured infusions, which are instantly reddened by the presence of an acid, without occasioning the slightest change of colour. The same happens also with alkalies.

By the powerful action of a large galvanic battery, the illustrious Sir H. Davy, Professor of the Royal Institution, effected the decomposition of the fixed alkalies, which had previously been attempted in vain. A small bit of alkali is laid on a plate of platina connected with one end of the battery, and on bringing another piece of platina connected with the other end of the battery into contact with it. A portion of black matter is soon formed in which is found embedded small metallic globules, which substance is found to be the base of the alkali, and has been deprived of its oxygen by the galvanic agency. This base is found to be a metal: that obtained from potass is denominated *potassium*, and that which constitutes the base of soda is called *sodium*. These metals are very inflammable, and decompose water, with a bright flash and slight explosion.[1] The same ingenious philosopher in some degree succeeded in decomposing the alkaline earths.

The galvanic power exhibits most of the phenomena of electricity in a considerable degree: It gives a shock to the animal system, it sensibly affects the electrometer; it burns metallic and

[1] See the article *Chemistry*, where these substances are described.

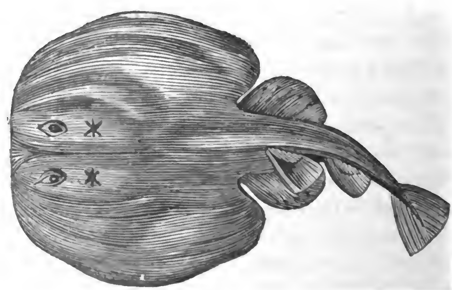
other combustible bodies; it exhibits a luminous spark, accompanied with a report, and it continues in action for a long time till the chemical action between the component parts of the battery is quite exhausted.—The following are some of the effects produced by this power on the human body. If we immerse a wire that proceeds from one extremity of a battery in a basin of water in which we plunge one of our hands, and then grasp with the other hand, well moistened, a large piece of metal, as a silver spoon, and touch the other end of the battery with it, a shock will be distinctly felt. This shock resembles very nearly the sensation produced by a very large electrical battery weakly charged. If the communication is made with any part of the face near the eyes, or with a silver spoon held in the mouth, a vivid flash of light is perceived at the moment of contact, and that whether the eyes be open or shut. —Instead of one person, a number of persons may at once receive the shock. They have only to join their hands—well moistened with water, and when the circuit is completed, they will all feel the shock at the same moment. But the strength of the shock is considerably diminished by its passing through a great number of persons. The shock from a battery consisting of fifty or sixty repetitions of the most active combinations may be felt as far as the elbows, and the combined force of five or six such batteries, will give a shock much stronger than most men would be willing to receive.—The flash to which I have adverted appears very strong, when a wire which proceeds from one extremity of the battery, is held between the teeth and rests upon the tongue, whilst the other wire is held in the hand. In this case, the lips and tongue are convulsed, the flash appears before the eyes, and a very pungent taste is perceived in the mouth.

The effects of galvanism upon the functions of secretion are the most remarkable, and at the same time the most difficult to be explained. That it acts especially, and in a peculiar manner upon the gastric juice, a fluid essentially subservient to the process of digestion is universally admitted; and therefore it has been supposed that the various functional parts of the body form a sort of galvanic battery, by which a regular circulation of this subtile and mysterious fluid is maintained. On this ground galvanism has been applied, in various instances, with good effect, in the case of nervous disorders. Tic doloureaux, which is considered a chronic derangement in the nervous energy, has been subjected to the in-

fluence of galvanic currents, and, in particular cases, the complaint has in this way been completely removed.

The action of galvanic batteries is the strongest when they are first filled with the fluid and it declines in proportion as the metals are oxidated or the fluid loses its power. Of course, after a certain time the fluid must be changed, and the metal cleaned, either with sand, or by immersing them a short time in diluted muriatic acid. Care must always be taken to wipe quite dry the edges of the plates to prevent a communication between the cells; and it will be found that the energy of the battery is in proportion to the rapidity with which the zinc is oxidated.

It has been considered as highly probable, if not certain, that in the structure of the *Gymnotus* or *electrical eel*, and in the *Torpedo*, or *electrical ray*—arrangements are given to those remarkable animals for the purpose of defence, which nearly resemble the Voltaic apparatus; for they consist of many alternations of different substances.—The torpedo, which belongs to the order of



THE TORPEDO.

rays, is a flat fish, seldom twenty inches in length, weighing only a few pounds when full grown, and is found in various parts of the sea-coast of Europe. Its electric organs are two in number, and placed, one on each side of the cranium and gills, reaching from thence to the semicircular cartilages of each great fin, and extending longitudinally from the anterior extremity of the animal to the transverse cartilage which divides the thorax from the abdomen. The length of each organ is somewhat less than one third

part of the length of the whole animal. Each organ consists of perpendicular columns, reaching from the under to the upper surface of the body, and varying in length according to the thickness of the fish in various parts. The number of these columns is not constant. In a very large torpedo one electric organ was found to consist of 1182 columns—the greater number of which are either irregular hexagons or irregular pentagons, their diameter being about one-sixth of an inch. These electric organs seem to be the only parts employed to produce the shock, the rest of the animal appearing to be only the conductor of that shock, and by artificial electricity it has been found that the animal is a conductor of the electric fluid. The *Gymnotus electricus*, or the electrical eel, is found in the great rivers of South America. Humboldt, in his personal travels in South America, furnishes us with an interesting account of the mode of catching these eels, and of certain experiments which were made upon them. Some of the gymnoti which he measured exceeded five feet in length, and the transverse diameter of the body was more than three inches; and a fish four feet one inch long weighed fifteen and three quarter Troy pounds. The skin of the animal is constantly covered with a mucous matter, which it appears conducts electricity more than twenty times as well as pure water.

We may next notice some of the electric effects which resulted from various experiments made on these animals. It is understood that first shocks from large and strongly irritated gymnoti ought as much as possible to be avoided; and if by chance a stroke is received, the pain and numbness is so violent as to exceed all description. Humboldt informs us that he never received so severe a shock from common electricity as he experienced from having incautiously placed both his feet on the body of the animal just taken from the water, and that he was afflicted for the rest of the day by a violent pain in almost every joint. When in a state of great weakness the animal produces in the person who touches it a twitching which is propagated from the hand to the elbow; a kind of internal vibration lasting two or three seconds, and followed by painful torpidity being felt after every stroke. The electric energy appears to depend upon the will of the creature, each shock being accompanied with a depression of the eyes. The organ acts only under the immediate influence of the brain and heart; for when one of them was cut

through the middle, the fore part of the body alone gave shocks. Its action on man is transmitted and intercepted by the same substances that transmit and intercept the electrical current of a conductor charged by a Leyden jar or a Voltaic pile. In the water the shock can be conveyed to a considerable distance.[1]

By means of the galvanic agency a variety of striking and surprising effects have been produced, some of which we have already noticed, and of which the following is a brief summary. Gunpowder, cotton, and other inflammable substances have been set on fire—charcoal has been made to burn, with a most brilliant and beautiful white flame—water has been decomposed into its elementary parts—metals have been melted and set on fire—fragments of diamond, charcoal, and plumbago, have been dispersed, as if they had been evaporated—platina, the hardest and heaviest of the metals, has been melted as readily as wax in the flame of a candle—the sapphire, quartz, magnesia, lime, and the firmest compounds in nature, have been made to enter into fusion. —Its effects on the animal system are no less surprising. When applied to a fowl or a rabbit, immediately after life is extinct, it produces the most strange and violent convulsions on the nervous and muscular system, as if the vital functions were again revived: and when applied to the human body after death, the stimulus has produced the most horrible contortions and grimaces in the muscles of the head and face; and the most rapid movements in the hands and feet.

Numerous experiments, which have been made both on dead animals and on human subjects, have led to the conclusion that galvanism possesses some *sanative* as well as energetic influence on the actions of diseased living beings. It has been found to effect cures, and to afford relief in nervous disorders. It has not only been used to cure the afflicted living, but also to resuscitate the apparently dead; and in all cases of suspended animation, from accidents or otherwise, it has been found to be a test of vitality, and the surest criterion of recent death. A celebrated medical writer on this subject, in Berlin, strongly recommends its use in rheumatism, palsies, nervous deafness, hoarseness, debility of sight, white swellings of the joints, tumours in the glands of the neck, and several other disorders. It is found that it possesses not only a stimulating power over the nerves and muscles, but also

1 Humboldt's Personal Narrative, pp. 198, 199, Oliver and Boyd's edition.

over the vital forces. M. Spronger, of Jenna, gives an account of his having restored the sense of hearing to forty-five persons by means of this singular agent—to four of whom he also restored the sense of smelling—Galvanism has also been employed as a powerful agent for blasting rocks. At Glasgow, and several other places, its agency has been applied with great success. At one blast hundreds of tons of stones have been in a moment loosened from the rock. It is found that dry sand is quite sufficient for filling the perforation in the rock where the charge is placed, and that the process is unaccompanied with the smallest degree of danger, so that, by this mode of blasting, those accidents which have so frequently happened to workmen employed in such operations may be entirely prevented.

The galvanic agency enables us to account for the following among other facts:—Why porter has a different and more pleasant taste when drunk out of a pewter vessel than out of glass or earthenware,—why a silver spoon is discoloured when used in eating eggs,—why the limbs of people under amputation are sometimes convulsed by the application of the instruments,—why pure mercury is oxydized when amalgamated with tin,—why works of metal, which are soldered together, soon tarnish in the places where the metals are joined,—and why the copper sheathing of ships, when fastened with iron nails, is soon corroded about the place of contact. In all these cases a galvanic circle is formed which produces the effects. The plating of iron plates with zinc by the action of the galvanic trough—termed galvanized iron in commerce—is one of the many useful purposes to which this science has been applied. By this means the destruction of the iron by rust has been avoided. We have reason to believe that, in combination with the discoveries which modern chemistry is daily unfolding, the agencies of this fluid will enable us to carry the arts forward towards perfection, and to trace the secret causes of some of the sublimest phenomena of nature.

Magnetism.

This department of philosophy describes the phenomena and the properties of the *loadstone*, or natural magnet. The natural magnet is a hard dark-coloured mineral body, and is usually found in iron mines. The following are some of its characteristic pro-

perties:—1. It attracts iron and steel, and all substances which contain iron in its metallic state. 2. If a magnet be suspended by a thread, or nicely poised on a pivot, or placed on a piece of wood, and set to float in a basin of water, one end will constantly point nearly towards the north pole of the earth, and the other towards the south; and hence, these parts of the magnet have been called the *north* and *south poles*. 3. When the north pole of one magnet is presented near to the south pole of another, they will *attract* each other; but if the north pole of one be presented to the north pole of another, or a south pole to a south, they will *repel* each other. 4. A magnet placed in such a manner as to be entirely at liberty, inclines one of its poles to the horizon, and of course elevates the other above it. This property is called the *dipping* of the magnet. 5. Magnets do not point directly north and south; but in different parts of the world with a different *declination* eastward or westward of the north: it is also different at the same place at different times. In London, and in most places of Great Britain, the magnetic needle in 1824 pointed about twenty-four degrees to the west of the north. For more than 160 years previously it had been gradually declining from the north to the west; but seemed then to have begun its declination to the eastward. 6. Any magnet may be made to communicate the properties now mentioned to any piece of iron or steel. For example, by gently rubbing a penknife with a magnet, it will be immediately invested with the property of attracting needles, or small pieces of iron or steel. 7. Heat weakens the power of a magnet, and the gradual addition of weight encreases the magnetic power. 8. The properties of the magnet are not affected either by the presence or absence of air; and the magnetic attraction is not in the least diminished by the interposition of any bodies except iron. A magnet will equally affect the needle of a pocket compass when a thick board is placed between them as when it is removed. It has been lately discovered that the *violet rays of the solar spectrum*, when condensed with—or, by means of a convex glass, and made to pass along a piece of steel, have the power of communicating to it the magnetic virtue. In ships made of iron, the compass needle has been found to vary; allowance must therefore be made in navigation for such variation.

It appears from numerous observations that the magnetic needle is subject to a *diurnal variation*. From the experiments and ob-

servations made in different parts of Europe by Graham, Wargentin, Canton, Van Swieten and others at different periods, it appears that the north pole of the needle begins to turn westward at seven or eight o'clock in the morning, and continues to deviate in that direction till about two o'clock, when it becomes stationary, and soon begins to turn eastward, arriving at the position it had in the morning, at the same hour in the evening. The observations of Mr. Canton showed that the amount of this deviation varied from seven to thirteen or fourteen minutes, being greatest at mid summer, and least at mid-winter, and encreasing and decreasing gradually between these seasons. The same phenomenon has been more recently observed by Colonel Beaufoy, Professor Hansteen, and others. Cassini, who observed the diurnal variation at Paris, found that neither the solar heat nor light influenced it; for it was the same in the deep caves constructed under the observatory at Paris, where a sensibly constant temperature is preserved, and from which light is excluded, as at the surface.—In northern regions these diurnal changes are greater and more irregular, while towards the Equator their amplitudes are gradually diminished till at length they disappear. The direction of the needle is said to be affected by approaching earthquakes, or eruptions of volcanoes.

The inclination or *dip* of the needle—that is, its deviation from the horizontal plane—affords a manifestation of the influence exercised upon it by the magnetism of the Earth. Mr. R. Norman, in 1576, first discovered the *dip* of the needle, and found that, in London, it amounted to seventy-one and a-half degrees, that is, its north pole bent downwards below the level of the horizon, forming an angle with it to this extent, when left free to move on an axis perpendicular to the magnetic meridian. If the magnetic instrument be carried northward it is found that the dip gradually encreases; and on reaching a certain region near the pole, the needle would become vertical, the dip being ninety degrees, and its north pole pointing downwards. At such a place, the common compass needle, moving on a vertical support, would lose its directive power, and rest indifferently in any position. A place where these effects would be produced is called a *Northern Magnetic Pole.*—If, on the other hand, the dipping needle were carried towards the equator, the magnitude of the *dip* would be gradually diminished, till, on arriving at a certain region near the

equator, the needle would become horizontal, and the dip would become nothing, and if the dipping needle could be carried round the globe, always following such a course as would allow it to retain its horizontal position, its course traced on the globe would be the *Magnetic Equator.*

The cause which produces these singular properties of the magnet has hitherto remained a mystery; but the knowledge of the *polarity* of the magnet has been applied to a most important practical purpose. By means of it, man has now acquired the dominion of the ocean, and has learned to trace his course through the pathless deep to every region of the globe. There can be little doubt, that magnetism has an intimate connexion with electricity, galvanism, light, heat, and chemical action; and the discoveries which have been already made, and others to be expected, from the experiments of Morichini, Oersted, Abraham, Hansteen, Barlow, Beaufoy, Ampere, and Scoresby, promise to throw some light on this mysterious agent, and on the phenomena of nature with which it is connected.

Electro-Magnetism.

This is a new science founded on the connexion which is now ascertained to subsist between Electricity and Magnetism. In the year 1819, Professor Oersted of Copenhagen discovered that, when a wire conducting electricity is placed parallel to a magnetic needle, properly suspended, the needle will deviate from its original or natural direction. 1. If the needle be *above* the conducting wire, and the positive electricity goes from right to left, the *north* end of the needle will be moved *from* the observer, or to the *west.* 2. If the needle is *below* the wire, and the electricity passes as before, the *north* end of the needle will be moved *towards* the observer, or to the *east.* 3. If the needle is in the same horizontal plane with the wire, and is between the observer and the wire, the *north* end of it will be *elevated.* 4. If the needle is similarly placed on the opposite side, the north end of it will be *depressed.* From these facts M. Oersted concludes, that the magnetical action of the electrical current has a circular motion round the wire which conducts it.—When these experiments were commenced, and repeated, and varied by other philosophers, a multitude of new facts were soon brought to light through the

labours of Davy, Faraday, Ampere, Barlow, Biot, and other experimentalists. Two very important facts were ascertained by Ampere and Davy—that the conjunctive wire itself becomes a magnet —and that magnetic properties might be communicated to a steel needle not previously possessing them, by placing it in an electrical current. The former of these facts is proved by throwing iron filings on paper and bringing them under the wire, when they will immediately adhere to it, forming a tuft round it ten or twelve times the diameter of the wire. On breaking the connexion with the battery, however, they immediately fall off, proving that the magnetic effect depends entirely on the passage of the electricity through the wire. The degree of force of the magnetic property thus communicated to the uniting wire, is considered by Sir H. Davy, to be proportional to the quantity of electricity transmitted through it. Hence the finer the wire the more powerfully magnetic was it rendered; and hence also a battery of very large plates was found to give the strongest magnetism to the wire connecting its poles.

The following are some of the results of experiments which have been made on this subject:—1. The deviation of the magnetized needle is greater or less, according to the nature of the conducting wire; and copper appears to be of all metals that which produces the most powerful effects. 2. The intensity of an electrical current is constant throughout the whole of a homogeneous wire whatever may be its length. 3. If two homogeneous conductors be *simultaneously* adapted to the same galvanic pile—first, the absolute intensity of the current decreases in the inverse ratio of the square root of the length of the wire—and secondly, when the thickness of the wires is altered, the intensity of the current encreases with their diameter to a certain limit beyond which an encrease of thickness no longer produces any change in the intensity of the current. 4. When the conjunctive wires of two distinct galvanic arrangements are made to approach each other, magnetic attractions and repulsions are observed. Two wires of copper, silver, or any other metal, connecting the extremities of two galvanic troughs, being placed parallel to each other, and suspended so as to move freely, immediately attract and repel each other, according as the directions of the currents of electricity flowing through them are the same or different.—On this experiment is founded the most plausible and rational theory of mag-

netism, namely, that *it arises from the attractions and repulsions of currents of electricity constantly circulating round every magnet.* This is considered as explaining the reason why the magnetic needle places itself at right angles to a wire conducting electricity, namely, that the electric current passing along the wire may coincide with that circulating round the magnet.

These, and a great number of other facts, it is presumed, clearly demonstrate the perfect resemblance, or rather identity of electricity and magnetism. Magnetic phenomena are thus in fact, a series of electrical phenomena, and magnetism may, with propriety, form a branch of electricity under the head of *Electrical currents.* Currents of electricity, according to this theory, are essential to the production of magnetic phenomena; but these are not obvious in a common magnet. M. Ampère has suggested their existence, however, and has so arranged them theoretically as to account for a great proportion of magnetic appearances. A magnet he conceives to be an assemblage of as many electrical currents moving round it in planes perpendicular to its axis, as there may be imagined lines, which, without cutting one another, form close curves round it. A permanent magnet, then, may be conceived to be *a mass of iron or steel round the axis of which electrical currents are continually circulating, and these currents attract all other electric currents flowing in the same direction, and repel all others which are moving in an opposite direction.* One important circumstance is always to be kept in view, that the electric currents flow round every magnet in the same direction in reference to its poles. If, for instance, we place a magnet with its north pole pointing to the north, in the usual position of the magnetic needle, the current of electricity flows round it from west to east—or in the direction in which the planets revole and the earth on its axis—or, on the western side of the magnet, it is moving upwards, and on the eastern side downwards; on the upper side from west to east, and on the lower side from east to west. This is ascertained to be a uniform law, and on these principles most of the phenomena of magnetism may be accounted for.

To complete the view of Ampère's doctrine on this point, it remains only to explain the influence of the earth on the magnet by which the needle is kept always in one position, nearly coinciding with the meridian. He maintains that currents of electricity, analogous to those which circulate round every magnet, are con-

stantly floating round the globe, as the current of electricity in a galvanic apparatus moves in an unbroken circuit from the negative to the positive pole, and from it by the connecting wire round again to the negative pole. The direction of these currents he infers to be the same as has been stated with artificial magnets; and it is simply by the attractions and repulsions of these terrestrial currents bringing the currents round the needle to coincide with them, that the latter always points to the north. The cause of these electric currents thus inferred to be constantly circulating round the globe is, as yet, involved in obscurity. They are supposed to move at right angles to the magnetic meridian, or nearly parallel with the equator, on the eastern side of the earth moving from us, and on the western side flowing towards us. It is conjectured that the arrangement of the materials of the globe may be such as to constitute a battery, existing like a girdle round the earth, which, though composed of comparatively weak materials, may be sufficiently extensive to produce the effects of terrestrial magnetism. Its irregularity, and the changes it may accidentally or periodically suffer, may explain the phenomenon of the variation of the compass; or the general action producing the currents of electricity may be affected by different causes, as the motions of the earth, the currents of the atmosphere, the process of evaporation, and the solar heat. It may also be supposed that much of the variation depends on the progress of oxidation in the continental regions of the globe.

In connexion with the principles and phenomena stated above—by means of a galvanic battery, *iron may be temporarily magnetized*—in other words, endowed with an attractive power, so long as it is kept in connexion with the galvanic apparatus. A magnet of this kind is generally formed in the shape of a horse shoe; and when suspended so as to present the extremities downwards, and when the galvanic communication is established, the magnetic power is instantly exerted, and a bar of iron held to the extremities will be immediately attracted, and firmly adhere. But, on loosening the connexion with the battery, the magnetic power is instantly destroyed, and the ball of iron falls to the ground. Such magnets, which have obtained the name of *Electro-magnets*, have been thus made, endowed with very great attractive power, so as to sustain, in some cases, a weight of above 2000 pounds, or nearly a ton. These magnets, like those which possess permanent

magnetism, have opposite poles, one attracting and the other repelling.

This science of Electro-magnetism has opened up new and more expansive views to the philosophic world, in reference to the powers of Electricity, Galvanism, and Magnetism, and their relation to each other; and in the progress of the investigations which are now going forward, we have reason to hope that some of the hitherto latent principles which pervade our terrestrial system will be unfolded, and the diversified phenomena they produce more fully explained and illustrated. It is probable, too, that the arts will be improved by the application of the principles which this science has brought to light; and they have already been applied to machinery to produce rotatory and impulsive motions.

The Electric Telegraph.

The great discovery of the present century is undoubtedly the Electric Telegraph, whose wires now carry intelligence over the whole of Europe and America—across vast tracts of country, and even under the great sea itself. A few words, therefore, on this wonderful agency, will not be out of place. What has been already stated, will have informed our readers of the general properties of Electricity; consequently it will only be necessary for me to touch lightly on the *modus operandi* of telegraphic communication.

The electric fluid is known to exist in unlimited quantities in all parts of the earth, the air, and the waters; and for the purpose of evolving this fluid, and bringing it under control, various apparatus have been invented. But without noticing these different plans, I will endeavour to explain the method of communicating news, etc., from place to place by means of the Electric Telegraph. The electric fluid, obtained by means of the Galvanic or Voltaic battery, must be treated like any other fluid, which may be transmitted by pipes—the galvanic trough being the boiler or reservoir. If an iron or copper wire be coated with silk, wax, or gutta percha, it forms such a tube along which the electricity will pass freely. If the wire be covered, then, with a non-conducting substance, and prevented from passing into the earth by being carried in tubes underground, or from post to post above on the

lines of railroad—insulators of glass or earthenware being used to fix the wire to the posts for support—a stream of electricity may be carried from place to place. It must be borne in mind, that the stream of electricity will pass along the wire provided the other end of the wire be connected with the other end of the battery by means of a conductor. Practically, the earth itself forms the conductor which completes the electric circuit.

In order to transmit messages from place to place along the telegraphic wire, a simple mechanical arrangement is resorted to, whereby the deflections of the needle are made to represent either signs or letters of the alphabet. The telegraphic instrument is worked on the principle discovered by Oersted, that a magnetic needle lying parallel to a wire tends to place itself across such wire when a current of electricity is passed through it, and that the direction or motion of the needle is determined by the duration of the current through the wire. On this, and modifications of the same principle, all electric telegraphic communication is carried on: and when we consider the thousands of miles through which the electric current is carried, our wonder and admiration of the adaptations of modern science may well be expressed. To explain fully the various details of telegraphy would require a volume, and for further information on the subject, we refer the reader to Dr. Lardner's excellent MUSEUM OF SCIENCE AND ART.

Communication by means of the Electric Telegraph is now carried on all over Europe and America; and even in India and Australia, the telegraphic wires are in daily operation. In the British Isles all the important towns are connected, either by means of wires carried along the railways, or through tubes and tunnels under ground. In the United States, the most distant towns and cities are brought into instant contact. The continent of Europe and the British Isles are now distant from each other only a minute of time, and submarine wires, safely encased in gutta percha tubes and iron cables, pass from land to land, and carry intelligence and civilization through the invisible depths of the mighty ocean! From the Seat of War, in the Black Sea, to London, the centre of the commerce, science, and wealth of the world, is, as it were, but a step; and by the aid of science we hope to see the day when not only will the telegraphic wires be extended from England to America and India, but the whole earth engirdled with

the wondrous fluid which carries civilization and humanizing influences wheresoever it extends.

In transmitting the electric influence through wires—however great the distance—the time occupied in the transmission is nearly the same, for there is reason to believe that it flies with the same velocity as *light*, whose rate of motion is nearly two hundred thousand miles in a second. Were wires extended from Britain to China, on the one hand, and to America on the other, intelligence could be transmitted to those regions in as short a time as in conveying it across a garden or a large hall. It is hard to say to what extent signals may, in point of fact, be communicated in this way, in the course of improvements which are now going forward. Were the nations of Europe living in perfect amity and peace, and in a friendly communication with each other, telegraphs might be ramified throughout the whole extent of the civilized world; and the expense of constructing them would be but a slight item compared with the millions expended in the useless parade and crime of war, and the folly and sin of ambition.

Thus, it appears that the same physical principle or agent that produces the lightning and all the dread phenomena of the thunder storm—which rends asunder the mighty oak, and strikes with death both men and animals—which displays its terrific energy in the awful volcano, the fearful hurricane and the destroying earthquake, is the same as, subdued by science and human art, is rendered useful to society in a vast variety of ways, and in no way more prominently than in the Electric Telegraph!

Such is a faint outline of some of the interesting subjects which Natural Philosophy embraces. Its relation to Religion will appear from the following considerations:

1. Its researches have led to the invention of machines, engines, and instruments of various kinds, which augment the energies, increase the comforts, and promote the general improvement of mankind; and these objects are inseparably connected with the propagation of Christianity through the world. If we admit that, in future ages, the religion of the Bible will shed its benign influence over all nations—that the external condition of the human race will then be prosperous and greatly meliorated beyond what it has ever been—and, that no *miraculous interposition* of Deity is to be expected to bring about such desirable events—it will follow, that such objects can be accomplished only

in the ordinary course of providence, by rational investigations into the principles and powers of Nature, and the application of the inventions of science to the great objects of religion and of human improvement, as I shall endeavour briefly to illustrate in the following chapter. As the destructive effects of many physical agents, in the present constitution of our globe, are doubtless a consequence of the sin and depravity of man—we have reason to believe that, when the economy of nature shall be more extensively and minutely investigated, and the minds of men directed to apply their discoveries to philanthropic and religious objects, they will be enabled to counteract, in a great measure, those devastations and fatal effects which are now produced by several of the powers of nature. The general happiness of all ranks, which will be connected by the universal extension of Christianity, necessarily supposes that this object will be accomplished; for, were a dread of destruction from the elements of nature frequently to agitate the mind, as at present, no permanent tranquillity would be enjoyed; nor would that ancient prediction, in reference to this era, receive its full accomplishment, that "there shall be *nothing to hurt or destroy* in all God's holy mountain, when the earth shall be full of the knowledge of the Lord." And since miraculous interpositions are not to be expected, to what quarter can we look for those subordinate agencies by which this object is to be effected, but to the discoveries and inventions of philosophical science!

Science has already enabled us to remedy many of those evils which are the accidental effects of the operation of physical agents. For example—the discoveries of the philosopher, with respect to the nature of the electric fluid, have enabled us to construct conductors for preserving buildings from the stroke of *lightning;* and we have every reason to hope that, in the progress of electric, galvanic, and chemical science, more complete thunder-guards, applicable to all the situations in which a person may be exposed, will be invented. Nay, our increasing knowledge of the electric fluid, and of the chemical agents which concur in its operation, may enable us to dissipate thunder-storms altogether, by disturbing the electricity of the clouds, by means of a series of elevated artificial conductors. This is not only possible, but has already been in some degree effected.

The electric fluid has also been, in many instances, successfully

applied in curing palsies, rheumatisms, spasms, obstructions, and inflammation; and it is known to have a peculiar effect on the nervous system. Lightning has been known to restore the blind to a temporary enjoyment of sight. Mr. Campbell of Succoth, in Dumbartonshire, who had been blind for several years, was led by his servant one evening through the streets of Glasgow during a terrible thunder-storm. The lightning sometimes fluttered along the streets for a quarter of a minute without ceasing. While this fluttering lasted, Mr. Campbell saw the street distinctly, and the changes which had been made in that part by taking down one of the city gates. When the storm was over, his entire blindness returned.—The following instance, stated by Professor Robison, as related by one of his friends, is no less remarkable. One evening in autumn he was sitting with a gentleman who had the same disorder as the gentleman mentioned above, and he observed several lambent flashes of lightning. Their faces were turned to the parlour window; and immediately after a flash the gentleman said to his wife, "Go, my dear, make them shut the white gate; it is open you see." The lady did so and returned; and, after a little said, "But how did you know that the gate was open?" He exclaimed with wonder, "I saw it open, and two men look in, and go away again"—which our friend also had observed—the gentleman, on being close questioned, could not recollect having had another glance, nor why it had not surprised him; but of the glimpse itself he was certain, and described the appearance very exactly.[1]

It is also possible that barren deserts might be enriched with fertility, and immense portions of the desolate wastes of our globe prepared for the support and accommodation of human beings, by arresting the clouds, and drawing down their electrical virtue and their watery treasure, by means of an extended series of elevated metallic conductors. What has been now stated is only one instance out of many which might be produced, of the extensive and beneficial effects which may be produced, in future ages, by the application of the discoveries of natural science.

(2.) A knowledge of Natural Philosophy enables us to detect *pretended* miracles, and to discriminate between those phenomena which are produced by the powers of nature, and the supposed effects of diabolical influence. It has been chiefly owing to ignor-

1 Sup. to Ency. Brit. 3rd edit. Art. *Thunder*—written by Dr. Robison.

ance of the principles of natural science, that mankind, in all ages, have been so easily imposed upon by pretenders to supernatural powers. It is owing to the same cause, that superstitious notions and vain alarms have spread their influence so extensively among the lower ranks of the population of every country. The pretended miracles by which Pagan and Popish priests endeavour to support the authority of their respective religious systems, and every species of degrading superstition, vanish into smoke, when examined by the light of modern science; and there can be no question, that an enlightened Missionary would, in many instances, find the principles and the instruments of natural philosophy important auxiliaries in undermining the fabric of heathen idolatry and priestcraft. They tend to dissipate a thousand idle terrors which haunt and agitate the human mind; to detect a thousand kinds of imposture by which it has been held in cruel bondage; and to prevent the perpetration of those deeds of cruelty which have uniformly marked the reign of Superstition.[1] Had our forefathers connected a knowledge of this subject with their study of the Scriptures, they would not have brought upon themselves that indelible disgrace which now attaches to their memories, on account of their having condemned and burned at the stake thousands of unhappy women, accused of crimes of which they could not possibly have been guilty.[2] In New England, towards the

1 Mr. Douglas, in his 'Hints on Missions,' suggests, that Natural Philosophy might be an important auxiliary to Christian Missionaries. "All the ancient 'war weapons of victory,' excepting miracles, are at their disposal; and new instruments of still greater potency, which the science of the latter days has been accumulating for a universal revolution of the mind are ready to be brought into action, upon a scale of overpowering magnitude. Even the single resource which is lost may yet be recompensed by equivalents, and a substitute, in many respects, may be found for miracles. The first effect of a miracle is, to rouse the attention, and to overawe opposing prejudices; the second, to afford a proof of religion of which it is a sealing accompaniment. *The first object might be gained by the natural magic of experimental philosophy;* and as to the second, the difference in the proof from miracles, lies rather in its being more circuitous, than in its being less conclusive at the present day than in the times of the Apostles." Mr. Moffat, missionary from Africa, expressed to the author sentiments similar to the above, and intimated his ardent desire that he might be furnished, before his return, with an apparatus for the purpose of expanding the minds of heathen converts in the knowledge of nature.

2 It has been calculated that, *in Germany alone,* the number of victims that suffered for the supposed crime of witchcraft from 1484—the date of

close of the 17th century, the witchcraft frenzy rose so high, that the execution of witches became a calamity more dreadful than the sword or the pestilence. Not only old women, but children of ten years, were put to death; young girls were stripped naked, and the marks of witchcraft searched for upon their bodies with most indecent curiosity; and those spots of the scurvy which age impresses on the bodies of old men were taken for evident signs of infernal power. So that ignorance of the laws and phenomena of nature has led even Christians to commit acts of injustice and horrid cruelty. For let it be remembered that it was *Christian* magistrates and ministers, under a pretended zeal for the honour of God, who sanctioned such cruel and unrighteous decrees. This consideration viewed in connexion with many others, tends to show, that the Christian revelation, considered abstractly by itself, without a reference to the visible system of the universe, is not sufficient for all the purposes of religion; as, on the other hand, the study of the works of nature is not sufficient of itself to lead the mind to the true knowledge of God, without the aid of the discoveries derived from the sacred oracles. For, although the Bible has been in the hands of Protestant Christians ever since the Reformation, yet it is only since the light of modern science began to diffuse its influence, that the superstitions of the dark ages, and the vulgar notions respecting witchcraft, necromancy, and other species of infernal agency, began to vanish, even from the minds of Christian teachers; as is evident from the writings of many eminent divines who flourished during the 16th and 17th centuries. As the two revelations which God has given throw a mutual lustre on each other, the one must always be considered as incomplete without the other. Both are necessary, in order "to make the man of God perfect," and to enable him to prosecute, with intelligence and success, the great objects of religion; and the Christian minister who affects to despise the aids of science in the cause of religion has yet much to learn with respect to some of the grand bearings of the Christian system.

3. The investigations of natural philosophy *unfold to us the incessant agency of God,* and the plans by which his wise and benevolent designs in the system of nature are accomplished. From the immeasurable globes of heaven, down to the minutest

the bull of Pope Innocent VIII, against witchcraft—till the beginning of the eighteenth century considerably exceeds *One hundred thousand!*

atoms, we perceive a regular chain of causes and effects, conspiring, in a thousand different modes, to accomplish the purposes of infinite wisdom and goodness. The operation of central forces, and of the law of gravitation on the earth and in the heavens—the hydrostatical laws which regulate the pressure and the motion of fluids—the chemical properties of the atmosphere, its undulatory, refractive, and reflective powers—the motion of the rays of light, and the infinite variety of effects they produce—the process of evaporation—the agencies of electricity and galvanism—the properties of the magnet, and the chemical action of acids and alkalies, and of the minutest particles of matter upon each other—ought to be viewed as so many modifications of the agency of Deity, and as manifestations of his wisdom, in carrying forward those plans which regard the interests of his universal kingdom; just as we consider the rise and fall of empires, the revolutions of nations, and the circulation of the Scriptures in heathen lands, as so many acts of his moral administration as the Governor of mankind. For, let it be carefully remembered that all these physical agencies have ultimately a moral and intellectual bearing; and are essentially connected with every other part of God's providential procedure.—Though we may be apt to consider them as so many detached and insulated pieces of machinery, with which we have little concern, or may even disdain to notice their mode of operation; yet, in the all-comprehensive mind of Him who takes in, at one glance, the whole chain of causes and effects, they are as essentially connected with his ultimate purposes, and the eternal destiny of man, as are the revelations of his word.—Were a single principle or motion which now animates the system of nature to cease—were the agency of electricity, for example, or the principle of evaporation, to be destroyed—the physical constitution of our globe would instantly be deranged; nature would be thrown into confusion; and the sentient and intellectual beings that now inhabit the earth would either be destroyed, or plunged into an abyss of misery. If therefore we admit that the *moral* agency of God is worthy of our contemplation, we ought to consider his physical operations also as no less worthy of our study and investigation; since they form the groundwork of all his other manifestations.

Chemistry.

This science, which is intimately related to the preceding, has for its object to ascertain the ingredients, or first principles, of which all matter is composed—to examino the compounds formed by the combination of these ingredients—to investigate those changes in natural bodics which are not accompanied with *sensible* motion, and the nature of the power which produces these combinations and changes.

Within the last century, the empire of Chemistry has been wonderfully extended. From an obscure and humble place among the objects of study, it has risen to a high and dignified station among those sciences which improve and adorn the human mind. No longer confined to the paltry and mercenary object of searching for the philosopher's stone, or of furnishing a little amusement, it now extends its sway over all the arts which minister to the comfort and improvement of social life, and over every species of animate and inanimate matter, within the range of human investigation. There is scarcely any science so immediately conducive to social improvement and human comfort. To whatever art or manufacture we turn our attention, we find that it has either been created by chemistry, or is indebted to its discoveries for some of its greatest improvements; and to whatever process in the material world we direct our investigations, the principles of this science, as deduced from modern experiments and discoveries, are capable of being applied. "The forms and appearances," says Sir Humphrey Davy, "of the beings and substances of the external world are almost infinitely various, and they are in a state of continued alteration. Even the earth itself, throughout its whole surface, undergoes modifications. Acted on by moisture and air, it affords the food of plants; an immense number of vegetable productions arise from apparently the same materials; these become the substance of animals; one species of animal matter is converted into another; the most perfect and beautiful of the forms of organized life ultimately decay, and are resolved into inorganic aggregates; and the same elementary substances, differently arranged, are contained in the inert soil; or bloom, and emit fragrance in the flower; or become, in animals, the active organs of mind and intelligence. In artificial operations, changes of the

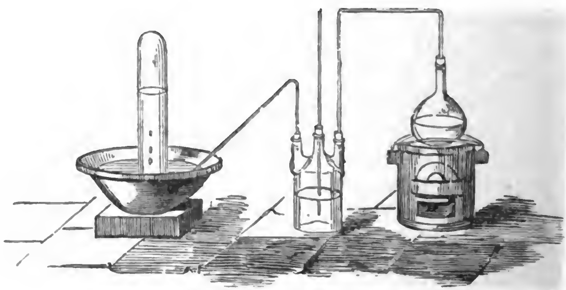
same order occur; substances having the characters of earth are converted into metals; clays and sands are united so as to become porcelain; earths and alkalies are combined into glass; acrid and corrosive matters are formed from tasteless substances; colours are fixed upon stuffs; or changed, or made to disappear; and the productions of the vegetable, mineral, and animal kingdoms, are converted into new forms, and made subservient to the purposes of civilized life.—To trace, in detail, those diversified and complicated phenomena; to arrange them, and deduce general laws from their analogies, is the business of Chemistry."[1]

Chemists have arranged the *general forms of matter* into the four following classes:—The *first* class consists of SOLIDS, which form the principal parts of the globe, and which differ from each other in hardness, colour, opacity, transparency, density, and other properties. The *second* class consists of FLUIDS, such as water, oils, spirits, etc., whose parts possess freedom of motion, and require great mechanical force to make them occupy a smaller space. The *third* class comprehends ELASTIC FLUIDS, or GASES, which exist freely in the atmosphere; but may be confined by solids and fluids, and their properties examined. Their parts are highly moveable, compressible, and expansive; they are all transparent; they present two or three varieties of colour; and they differ greatly in density. The *fourth* class comprehends ETHEREAL SUBSTANCES, which are known to us only in their states of motion, when acting upon our organs of sense, and which are not susceptible of being confined. Such are the *rays of light* and *radiant heat*, which are incessantly in motion, throughout the spaces that intervene between our globe, and the sun and the stars.—Chemists divide the substances in nature also into SIMPLE and COMPOUND. SIMPLE SUBSTANCES are those which have never yet been decomposed, nor formed by art. COMPOUND SUBSTANCES are those which are formed by the union of two or more simple substances. The following are all the *simple* substances with which we are at present acquainted: CALORIC, LIGHT, OXYGEN, NITROGEN, CARBON, HYDROGEN, SULPHUR, PHOSPHORUS, the METALS, and some of the EARTHS.—All that I propose under this article is simply to state some of the properties of two or three of these simple substances.

[1] Elements of Chemical Philosophy.

Caloric.

Caloric, or elementary fire, is the name now given by chemists to that element or property which, combined with various bodies, produces the sensation of *heat* while it is passing from one body to another. This substance appears to pervade the whole system of nature. There are six different sources from whence Caloric may be procured. It may be produced by *combustion*, in which process the oxygen gas of the atmosphere is decomposed, and caloric, one of its component parts, set at liberty—by *friction*, or the rubbing of two substances against each other—by *percussion*, as



CHEMICAL APPARATUS.

the striking of steel against a piece of flint—by *the mixture of two or more substances*, as when sulphuric acid is poured upon water or magnesia — by *electricity and galvanism*. The discharge of an electric or galvanic battery will produce a more intense degree of heat than any other means whatever. But the principal, and probably the original source of caloric, is the SUN, which furnishes the earth with a regular supply for the support and nourishment of the animal and vegetable tribes. From this source it moves at the rate of 192,000 miles in a second of time; for it has been already stated that the sun sends forth rays of heat which are distinct from those which produce illumination, and which accompany them in their course through the ethereal regions.

Caloric is the cause of *fluidity* in all substances which are capable of becoming fluid. A certain portion, or *dose* of it, reduces a

solid body to the state of an incompressible fluid; a larger portion brings it to the state of an aeriform or gaseous fluid. Thus, a certain portion of caloric reduces ice to a state of water; a larger portion converts it into steam or vapour. There is reason to believe that the hardest rocks, the densest metals, and every solid substance on the face of the earth, might be converted into a fluid, and even into a gas, were they submitted to the action of a very high temperature. This substance is called *sensible* caloric, when it produces the sensation of *heat;* and *latent* caloric, when it forms an insensible part of the substance of bodies. One of the principal effects of caloric is the *expansion* of bodies. All bodies, with a very few exceptions, are capable of expansion by means of heat; the gases being the most expansive, and solids the least susceptible of expansion. The expansion of gases or any aeriform substance is illustrated by the experiment of a half-blown bladder held before a fire, as stated under the article *Pneumatics.* The expansion of solids is illustrated by the following process: When the iron rim of a cartwheel is to be put on, it is first heated to a considerable degree. When hot, the circle is somewhat larger than when cold, and thus easily slips round the wheel; but, as it cools, the circle decreases, and firmly binds together the wood-work of which the wheel is composed. In reference to *fluid* bodies the same fact is exemplified in the *Thermometer*—the mercury or spirit of wine in which rises or falls in proportion to the quantity of heat which is applied to the instrument.—Other effects of heat are *liquefaction,* as when ice is converted into water—*vaporization,* as when water is converted into steam—*ignition,* as when bodies by heat are made to produce flame—and *evaporation,* when substances send off vapour from their surfaces at temperature below the boiling point. The heat of the sun and other causes produce this effect every day over the whole surface of the globe. An immense quantity of vapour is thus continually rising from the surface of the land and seas, which is either formed into clouds or condensed into rains or dew—which process is of most essential service throughout the whole economy of the physical constitution of our globe.—All bodies are, in a greater or less degree, *conductors* of caloric. Metals and liquids are good conductors of heat; but silk, cotton, wool, wood, etc., are bad conductors of it. For example, if we put a short poker into the fire at one end, it will soon become hot at the other; but this will not happen with a piece of wood of the

same length, and under the same circumstances. A person with a silken purse, containing metal coin, may stand so near the fire as to make the metal almost too hot to touch, though the temperature of the purse will apparently be scarcely altered. If a hand be put upon a hot body, part of the caloric leaves the hot body and enters the hand, producing the sensation of heat. On the contrary, if a hand be put on a cold body, as a piece of iron, or another colder hand, part of the caloric contained in the hand leaves it to unite with the colder body, producing the sensation of cold. In short, caloric is diffused throughout all bodies, and enters into every operation in nature; and, were it not for the influence of this subtile fluid, there is reason to believe that the whole matter of the universe would be condensed into a solid mass.

Oxygen.

Oxygen is a very pure, subtile, and elastic substance, generally diffused throughout nature; but is never found unless in combination with other substances. It is one of the most important agents in nature; there being scarcely a single process, whether natural or artificial, in which oxygen has not some important share. When combined with caloric, it is called *oxygen gas,* which forms one of the constituent parts of the atmosphere. It is a permanently elastic fluid, transparent, colourless, and destitute of taste and smell; 100 cubic inches of it weighs 33·9153 grains, that is nearly thirty-four grains. And as the same bulk of common air weighs 30·8115 grains under the same circumstances, the specific gravity of oxygen is reckoned 1·1007, that of common air being reckoned 1·000, though some chemists have adopted 1·111 as its specific gravity compared with atmospheric air. In this state it forms the principle of *combustion,* producing the most rapid deflagration of all combustible substances. If a lighted taper be let down into a jar of oxygen gas, it burns with such splendour that the eye can scarcely bear the glare of light, and at the same time produces a much greater heat than when burning in common air. If a steel wire, or a thin file, having a sharp point, armed with a piece of wood in inflammation, be introduced into a jar filled with this gas, the steel will take fire, and its combustion will continue producing a most brilliant phenomenon. It has been proved, by numerous experiments, that this gas is so *essential* to combustion,

that no substance will burn in common air which has been previously deprived of its oxygen. It is also essential to the support of animal life; so that man, and all the inferior ranks of animated nature, may be said to depend upon this fluid for their existence. Its basis gives the *acid* character to all mineral and vegetable salts; and the *calcination* of metals is altogether effected by their union with oxygen. It constitutes the basis both of the atmosphere which surrounds the earth, and of the water which forms its rivers, seas, and oceans. It pervades the substance of all the vegetable tribes, and enables them to perform their functions; and, in combination with the different metals, serves the most important purposes in the useful arts. In the operation of this elementary principle, we perceive a striking display of the agency of the Creator, and of the admirable means which his wisdom has contrived for preserving in due order the system of nature. And as this wonderful substance is so essentially necessary to animal and vegetable existence, everything is so arranged as to produce a regular supply of it, notwithstanding its incessant changes, and the multifarious combinations into which it is continually entering.

One of the most extraordinary effects of oxygen appears, when it is combined, in a certain proportion, with nitrogen, so as to form the gaseous oxide of nitrogen, or what is commonly called *nitrous oxide* or "laughing gas." This gas consists of sixty-three parts nitrogen, and thirty-seven oxygen, by weight. When inhaled into the lungs, it produces an extraordinary elevation of the animal spirits, a propensity to leaping and running, involuntary fits of laughter, a rapid flow of vivid ideas, and a thousand delightful emotions, without being accompanied with any subsequent feelings of debility. This circumstance shows what a variety of delightful or pernicious effects might flow from the slightest change in the constitution of the atmosphere, were the hand of the Almighty to interpose in altering the proportion of its constituent parts; for atmospheric air is composed of seventy-nine parts of nitrogen and twenty-one of oxygen, which is not a very different proportion from the above. Another gas called *nitric* oxide, composed of fifty-six parts oxygen and forty-four nitrogen, produces instant suffocation in all animals that attempt to breathe it. One of the most corrosive acids, the *nitrous* acid, or aquafortis, is composed of seventy-five parts oxygen and twenty-five parts nitrogen; so that we are every moment breathing a certain substance, which, in another

combination, would produce the most dreadful pain, and cause our immediate destruction. What a striking proof does this afford of the infinite comprehension of the Divine mind, in foreseeing all the consequences of the elements of nature, and in directing their numerous combinations in such a manner as to promote the happiness of animated beings.

Nitrogen.

Nitrogen, or *azote*, is a substance generally diffused throughout nature, and particularly in animal bodies. It is not to be found in a solid or liquid state, but, combined with caloric, it forms *nitrogen gas*, which is one of the ingredients of the atmosphere. It enters extensively into combination with various substances; it is an abundant element in animal matter; and its existence in such large quantity is a chief distinction between the constitution of the substances which compose animal and vegetable matter. Its specific gravity is 0.9748, which is lighter than common atmospheric air, and therefore ascends in it. Were it heavier it would accumulate to such a degree in our apartments as to be pernicious and even destructive to our health and existence. It is incapable of supporting either flame or animal life. This is proved by introducing an animal, or a burning candle, into a vessel full of this gas; in which case the animal is suddenly suffocated, and the candle instantly extinguished. It is this gas which is expelled from the lungs at every expiration, and rising over our heads, soon enters into new combinations. Though it is destructive to animal life, it appears to be favourable to plants, which vegetate freely when surrounded with nitrogen.

Hydrogen.

Hydrogen is another elementary substance, abundant in nature, and, when united to caloric, forms *hydrogen gas*. It is one of the constituent parts of *water;* for it has been completely demonstrated by experiment, that water is composed of eighty-five parts by weight of oxygen, and fifteen of hydrogen, in every hundred parts of the fluid. This gas was formerly known by the name of *inflammable air*. It is distinguished among miners by the name of

fire-damp; it abounds in coal mines, and sometimes produces the most tremendous explosions.[1] It is incapable by itself of sup-

THE SAFETY LAMP.

porting combustion, and cannot be breathed without the most imminent danger. It is the chief constituent of oils, fats, spirits, ether, coals, and bitumen; and is supposed to be one of the agents which produce the *ignes fatui,* and the *northern lights.* It is the

[1] It appears from the First Report of the 'Children's Employment Commission,' appointed by Parliament in 1842, that, *at the very least,* 1500 lives have been sacrificed in and about the Tyne and Wear collieries in the neighbourhood of Newcastle within the last forty years, chiefly by the explosions of hydrogen gas which have taken place in the coal-mines. To counteract such effects, Sir H. Davy, in 1815, displayed his ingenuity by the invention of his *Safety Lamp*—which is made of wire gauze, and has this particular property, that the miner may move about with it, and even work by its light in the midst of those explosive mixtures which have so often proved fatal, when entered with a common lamp or candle. But the want of accuracy in some of the manufacturers of the gauze with which the instrument is constructed, and the carelessness of the miners in using it, have frequently prevented its beneficial effects from being realized. For a particular description of this lamp, see ' Improvement of Society,' Sec. II, V, and the Appendix.

lightest of all ponderable bodies, being from twelve to fifteen times lighter than common air. A hundred cubic inches of it weigh about two and a quarter grains. On account of its great levity it is used for filling *air balloons*. In contact with atmospheric air it burns with a pale blue colour. When mixed with oxygen gas, it may be exploded, like gunpowder, with a violent report. *Carburetted hydrogen gas*, which is *carbon* dissolved by hydrogen, is that beautiful gas which is now employed in lighting our streets, shops, and manufactories.

Carbon.

Carbon is another simple substance extensively diffused throughout nature. It is found pure and solid only in the *diamond;* but it may be procured in the state of *charcoal*, by burning a piece of wood, closely covered with sand, in a crucible. Carbon enters into the composition of bitumen and pit coal, and of most animal and some mineral substances; and it forms nearly the whole of the solid bases of all vegetables, from the most delicate flower to the stately oak. It is also a component part of sugar, and of all kinds of wax, oils, gums, and resins. It combines with iron in various proportions, and the results are, cast-iron and steel. Black lead is a composition of nine parts of carbon to one of iron; and is therefore called a *carburet* of iron. Carbon is *indestructible* by age, and preserves its identity in all the combinations into which it enters—*Carbonic acid gas* is a combination of carbon and oxygen. It is found in a state of combination with lime, forming limestone, marble, and chalk; and may be separated from them by heat or by means of the mineral acids. This gas, which was formerly called *fixed air*, is found in mines, caves, the bottoms of wells, wine cellars, brewers' vats, and in the neighbourhood of limekilns. It is known to miners by the name of *choke-damp*, and too frequently runs on deadly errands. It extinguishes flame and animal life. It is the heaviest of all the gases; being nearly twice the weight of common air, and twenty times the weight of hydrogen. It may therefore be poured from one vessel to another; and a lighted taper is instantly extinguished by pouring a small quantity of it over the flame. It is a powerful *antiseptic*, or preserver from putrefaction. Meat which has been sealed up in it, (says Mr. Parkes,) has been known to have pre-

served its texture and appearance for more than twenty years. There is no substance of more importance in civilized life than the different forms of *Carbon.* "In nature," says Sir H. Davy, "this element is constantly active in an important series of operations. It is evolved in fermentation and combustion, in carbonic acid; it is separated from oxygen in the organs of plants; it is a principal element in animal structures; and is found in different forms in almost all the products of organized beings."

Chlorine.

Chlorine is a gas of a greenish colour. It is fatal to animal life, if breathed undiluted with common air, but it does not, like nitrogen and carbonic acid gas, extinguish combustion. A candle burns in it with a red flame; and it possesses the remarkable property of setting fire to many of the metals, even at the common temperature of the air, when introduced into it beaten out into thin leaves or reduced to filings—such as copper, tin, arsenic, zinc, and antimony. It has the property of destroying all vegetable colours. If a vegetable *blue,* for instance, be exposed to its action, the colour is not changed to a *red,* as it would be by an acid,—nor to a green, as it would be by an alkali,—but it is totally destroyed. On this account Chlorine has been employed as a powerful agent in the art of bleaching; for if unbleached linens be properly exposed to its action, the matter which gives them their gray colour is destroyed. But if applied to its pure state, and not sufficiently diluted, it invariably destroys the strength and texture of the linens. The specific gravity of this gas, when free from watery vapour is 2·5, common air being 1· and 100 cubic inches of it about seventy-seven grains.

Iodine.

Iodine is the name of an uncompounded principle or element in chemistry. It remained undiscovered till 1812, when a manufacturer of saltpetre in Paris detected it in the ashes of sea weeds. It resembles chlorine in some of its properties, and is derived from a source which also supplies chlorine, both of them being of marine origin. It may be procured by drying and powdering common sea weed, and heating it with sulphuric acid. A *violet-*

coloured vapour rises, which if received in a cool vessel, will condense on its sides, and will form scaly crystals of a somewhat metallic lustre. These crystals are the substance in question; and from the violet colour of its vapour it is called *iodine*. Its specific gravity is 3.084; it melts at a heat a little above that of boiling water, at the temperature of 350° it boils and evaporates in a violet-coloured vapour. It stains the fingers yellow, and consumes the cork of the phial in which it is contained. Its smell is disagreeable, its taste acrid, it destroys vegetable colours, and it possesses poisonous properties. It has the property of forming a beautiful blue colour, when mixed with a little powdered starch, and diffused through cold water; and hence iodine and starch are used by chemists as mutual tests of each other's presence, even in the most minute quantity. It is also used extensive by the photographer.

Sulphur.

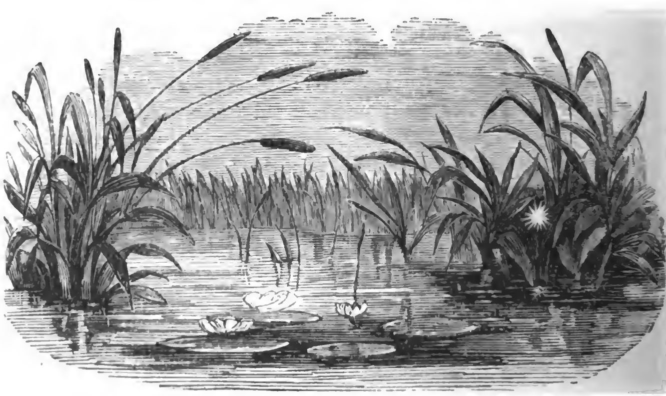
Sulphur is a substance which has been known from the earliest ages. It was used by the ancients in medicine, and its fumes have, for more than 2000 years, been employed in bleaching wool. It is found combined with many mineral substances, as arsenic, antimony, copper, and most of the metallic ores. It exists in many mineral waters, and in combination with vegetable and animal matters, but is most abundant in volcanic countries, particularly in the neighbourhood of Vesuvius, Etna, and Hecla in Iceland. It is a solid, opaque, combustible substance, of a pale yellow colour, very brittle, and almost without taste or smell. Its specific gravity is nearly twice that of water: it is a non-conductor of electricity, and, of course, becomes electric by friction. When heated to the temperature of 170° of Fahrenheit's thermometer, it rises up in the form of a fine powder, which is easily collected in a proper vessel, and is named the *flowers of sulphur*. It is insoluble in water, but may be dissolved in oils, in spirit of wine, and in hydrogen gas. When sulphur is heated to the temperature of 302° in the open air, it takes fire spontaneously and burns with a pale blue flame, and emits a great quantity of fumes of a strong suffocating odour. When heated to the temperature of 570°, it burns with a bright white flame, and emits a vast quantity of fumes. When these fumes are collected they are found to consist

entirely of *sulphuric acid;* so that sulphur, by combustion, is converted into an *acid.* It is the base of several compound substances. It unites with oxygen, hydrogen, nitrogen, phosphorus, the alkalies, the metals, and some of the earths. This substance is of great importance in medicine, as it is found to penetrate to the extremities of the most minute vessels, and to impregnate all the secretions. It is also used in the arts, particularly in bleaching and dyeing; it forms a very large proportion of gunpowder; and one of its most common, but not least useful properties, is that of its *combustibility,* by which, with the help of a tinder-box, light is almost instantaneously produced. As this substance has not yet been decomposed, it is considered by chemists, in the mean time, as one of the simple substances.

Phosphorus.

Phosphorus is another simple combustible substance, but is never found in a pure state in nature. It is commonly united to oxygen in the state of phosphoric acid, which is found in different animal, vegetable, and mineral substances. It was first discovered by Brandt, a chemist of Hamburgh, in the year 1667, and afterwards by the Honourable Mr. Boyle, in 1679. It was formerly obtained by a disgusting process; but is now extracted from the bones of animals, by burning them, and then reducing them to a fine powder, and afterwards pouring sulphuric acid upon them. This substance, when pure, resembles bees' wax, being of a clear, transparent, yellowish colour; it is insoluble in water; it may be cut with a knife, or twisted to pieces with the fingers; and it is about double the specific gravity of water. Its most remarkable property is its very strong attraction for oxygen, from which circumstance it burns spontaneously in the open air at the temperature of 43°; that is, it attracts the oxygen gas from the atmosphere, and heat and flame are produced. It gradually consumes when exposed to the common temperature of air, emits a whitish smoke, and is luminous in the dark; for this reason it is kept in phials of water; and as the heat of the hand is sufficient to inflame it, it should seldom be handled except under water. At the temperature of 99° it melts; it evaporates at 219°, and boils at 554°. When heated to 148° it takes fire, and burns with a very bright flame, and gives out a large quantity of white smoke, which

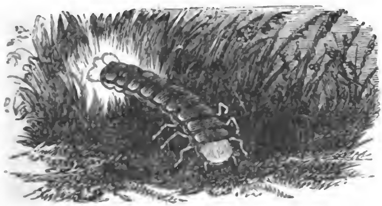
is luminous in the dark: at the same time it emits an odour, which has some resemblance to that of garlic; and this smoke when collected is proved to be an *acid.* It burns with the greatest splendour in oxygen gas, and when taken internally, it is found to be poisonous. If any light substance, capable of conducting heat be placed upon the surface of boiling water, and a bit of phosphorus be laid upon it, the heat of the water will be sufficient to set the phosphorus on fire. If we write a few words on paper, with a bit of phosphorus fixed in a quill, when the writing is carried into a dark room it will appear beautifully luminous. If a piece of phosphorus, about the size of a pea, be dropped into a tumbler of hot water, and a stream of oxygen gas forced directly upon it, it will under water display the most brilliant combustion that can be imagined. All experiments with phosphorus, however, require to be performed with *great caution.* This substance is used in making the common phosphoric or lucifer matches, phosphoric oil, phosphoric tapers, and various phosphoric fire-works. *Phosphorized hydrogen gas* is produced by bits of phosphorus remaining some hours in hydrogen gas. It is supposed to be that gas which is



" WILL-O'-THE-WISP."

often seen hovering on the surface of burial grounds and marshes, known in Scotland by the name of *spunkie,* and in England by that of *Ignis Fatuus, Will-o'-the-Wisp,* or *Jack with the Lantern.*

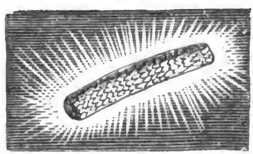
Some animals, as the *glow-worm* and the *fire-fly*, and fish in a putrescent state, exhibit phosphorescent qualities. M. Peron de



GLOW-WORM.

FIRE-FLY.

scribes a singular instance of this kind in an animal which he calls the *pyrosama Atlanticum*, which he observed in his voyage from Europe to the Isle of France. The darkness was intense when it was first discovered; and all at once there appeared at some distance as it were a vast sheet of phosphorus floating on the waves, which occupied a great space before the vessel. When the vessel had passed through this inflamed part of the sea, it was found that this prodigious light was occasioned by an immense number of small animals, which swam at different depths, and appeared to assume various forms. Those which were deepest looked like great red-hot cannon balls, while those on the surface resembled cylinders of red-hot iron. Some of them were caught, and were found to vary in size from three to seven inches. All the exterior surface of the animal was bristled with thick oblong tubercles, shining like so many diamonds; and these seemed to be the principal seat of its wonderful phosphorescence. There is also another substance of somewhat analogous character called Odyle, which is supposed to be evolved from decaying matter, which was lately discovered by the Baron Von Reichenbach during his experiments on magnetism.



PYROSAMA ATLANTICUM.

Metals.

The metals generally recognized by chemists are the following: —Gold, Silver, Iron, Copper, Lead, Tin, Zinc, Mercury, Platinum, Potassium, Sodium, Lithium, Calcium, Magnesium, Aluminum, Glucinum, Barium, Strontium, Yttrium, Thorinum, Zirconium, Nickel, Cerium, Uranium, Molybdenum, Tungsten, Columbium, Tellurium, Cadmium, Vanadium, Cobalt, Manganese, Chromium, Bismuth, Antimony, Palladium, Rhodium, Iridium, Osmium, Aluminium, and Arsenic.—Some of these metals are either useless in their own nature, or are so on account of the difficulty and expence of procuring them, or they are useful for a few purposes only. The metals called *Cerium, Uranium, Molybdenum, Tungsten, Columbium, Tellurium, Cadmium,* and *Vanadium,* on account of their scarcity, or from the difficulty of reducing them to the metallic state from their ores, are but imperfectly known, and have not yet been applied to any useful purpose. *Cobalt* is used for giving a blue colour to glass and porcelain; the tint is beautiful, and hence the metal bears a high price. *Manganese* is employed by glass-makers for two opposite purposes; for communicating a purple or violet colour; or for destroying all colour, and rendering the glass colourless. *Chromium* is used in coloured glass-making and porcelain painting, and also in enamelling. It communicates to glass and enamel a green colour, while it furnishes to the painter his most lively yellow. *Bismuth* is one of the most fusible of the metals, and it communicates fusibility to other metals. A mixture of tin, lead, and bismuth, is so fusible that it melts when thrown into boiling water. A toy of this kind has been contrived; it is a spoon, which, when immersed in a very hot liquid, immediately melts. An alloy, composed of three parts lead, two of tin, and five of bismuth, melts at 197°, and is used for taking casts from gems, seals, etc., and likewise for silvering the inside of glass globes: the compound, when gently heated in the globe, melts, and by rapidly turning the glass an equal coating may be laid on, which, when cold, hardens and adheres.—The uses of most of the other metals are generally known.

The following are some of the characters which distinguish metals from other bodies. They all possess that property understood by the expression *metallic lustre,* without which no substance

can be properly considered a metal. They are, for the most part, hard and heavy, and are all opaque; they are insoluble in water; they admit of being so highly polished as to reflect the light; they are capable of being melted by heat, and of recovering their solidity by cooling. They are of *different colours;* some are white, as platinum, palladium, nickel, silver, tin, and mercury; some are bluish white, as lead, zinc, iron, manganese, uranium, antimony; two are yellow, namely, gold and titanium; copper is red; bismuth is reddish; and cobalt has a paler reddish tint than bismuth. Three of the metals are magnetic, namely, iron, nickel, and cobalt. All the metals are rapid conductors of electricity. Some of them possess the property called *malleability,* or the capacity of being beaten out into sheets. Gold and silver may be beaten out into leaves almost inconceivably thin. Copper, tin, platinum, and lead, possess the same property, but less perfectly; others are totally destitute of it, as arsenic, antimony, columbium, and cobalt, and they can easily be reduced to a powder. Hence such bodies are denominated *brittle* metals. Some are possessed of a property nearly allied to this, called *ductility,* or the capability of being drawn out into fine wire. All the malleable metals possess this property: gold, silver, and iron may be drawn into wires much finer than human hair. Lead and zinc may be drawn into wires, but they cannot be made fine.

Metals differ much in their cohesion and hardness. Tungsten is so hard as to resist the file; it is a heavy metal procured from a mineral found in Sweden, and from an ore called *wolfram,* found in Cornwall. On the other hand, lead and tin may be scratched with the nail of one's finger. In regard to the *fusibility* of metals, they differ from each other as much as in any other respect. Some are almost infusible in the greatest heat of a furnace, as platinum, iridium, rhodium, and molybdenum. It requires a most powerful heat to melt manganese, nickel, and iron. Others melt long before they become red hot, as tin, lead, and bismuth; while potassium, at common temperature, is always an easily moulded soft solid, and mercury, in all ordinary temperatures, remains in a liquid state.—Metals combine with *oxygen,* but they differ very much in the facility with which they unite with it. Some, by mere exposure to the atmosphere, absorb its oxygen with great rapidity, as potassium and sodium; others more slowly, as iron, manganese, and arsenic, and lead and copper still more

slowly. Others do not oxidate by exposure to the air, unless at a high temperature, as tin, zinc, mercury, antimony, bismuth. Others again will not oxidate by exposure to air or heat, or by immersion in water, as gold, platinum, palladium, iridium; and silver is with great difficulty oxidized by heat.—By combining the metals with oxygen, we can invest them with new properties, and are enabled to employ these properties to promote the progress of the fine arts, by imitating the masterpieces of creation, in the production of artificial salts, spars, and gems of every colour and of every shade. For it is found that different metals, by their union with oxygen, acquired different colours, and the same metal attains a different hue, according to the portion of oxygen combined with it.

The metallic substances to which we have now adverted generally occur in the earth in what are called *veins*, and are seldom found in the pure metallic state, but generally in combination with other substances, in which case they are called *ores.*

From the variety of metals which abound on our globe, we derive manifold advantages. They are the great agents by which we are enabled to explore the bowels of the earth, and to examine the recesses of nature. Their uses are so multiplied, that they are become of the greatest importance in almost every department and every occupation of life. Our gas pipes and gas lamps, our railroads, our electric telegraphs, our steam vessels, and many other modern inventions, bear witness to their high utility. They are the instruments of all our improvements, and even of civilization itself, and are subservient to the improvement of the human mind in all its investigations and researches, and to its progress towards perfection. Without the use of the metals—particularly iron, and all that it has enabled us to achieve—we should never have risen from the ignorance and rudeness of the savage state.—The *variety* of metallic substances, and the numerous modifications and combinations of which they are susceptible, are not to be attributed to chance, but ought to be considered as the effect of the consummate wisdom and contrivance of the Almighty Creator. In these arrangements we plainly perceive that the organization of the world has been effected by divine goodness and beneficence, and that, in the variety of metallic substances, and the properties with which they are invested, the Creator had in view to supply the

wants, to minister to the comforts, and to promote the general happiness of the different ranks of his intelligent offspring.

Having made these general remarks respecting metals, I shall conclude this section by a brief description of two metals discovered by Sir H. Davy, which are endowed with peculiar properties. The first of the metals to which I allude has obtained the name of *potassium*. This metal may be obtained in various ways; the simplest is, to abstract oxygen from potash, by exposing a mixture of dry carbonate of potash, with half its weight of recently burned charcoal, to a strong heat in an iron bottle coated with Stowbridge clay, and having a pipe proceeding from the bottle, so contrived that it can be kept cold with ice, and the air excluded. Potassium distils over, which condenses into a solid metal. Its colour, when it is newly cut, is white like that of silver, but it rapidly tarnishes in the air. To be preserved from change, it must be kept under naptha, that substance not containing oxygen. Its most remarkable properties are—1. Its extreme *levity*, being the lightest known solid. Its specific gravity is only 0·865, water being 1·000. Therefore, although a metal, it is lighter than water, and when thrown into it, swims in it like a piece of soft wood. At ordinary temperatures, it may be moulded by the fingers; at 32°, the freezing point, it is brittle; at 150°, it melts perfectly; and it rises in vapour in a heat a little below that of redness. 2. Its most remarkable property is its taking fire the moment it comes in contact with water. When thrown upon water it acts with great violence, swims upon the surface, and burns with a beautiful white and red light mixed with violet, and runs along the surface like a globule of melted metal. Even when the water is frozen, the potassium is kindled the moment it touches it, as is beautifully illustrated by throwing a piece of it into a cavity made in ice. In these cases the water is decomposed, giving its oxygen to the potassium.—It inflames when gently heated in the air, burns with a red light, and throws off alkaline fumes. It burns spontaneously in chlorine, with intense brilliancy; and it is an excellenent conductor of electricity and of heat.—Potassium likewise combines with hydrogen, and forms a gas which spontaneously burns when allowed to pass into the air. It is always formed when water is decomposed by this metal, and it burns on the surface, or when potassium is strongly heated in hydrogen. When potassium and sulphur, or phosphorus, are heated together even in a vacuum,

they combine with the phenomenon of brilliant combustion, and form sulphuret and phosphoret of potassium, both of which burn when heated in air.

The other metal to which I alluded is *Sodium*. This metal may be obtained by any of the processes which afford potassium. Soda, from which it is procured,—sometimes called the *Mineral Alkali*,—is usually obtained by the combustion of sea weeds and of plants growing near the sea: the product of the former is kelp, of the latter barilla, which contain the alkali in union with carbonic acid, and from which it is separated by lime.—The metal *Sodium*, in many of its characters, resembles potassium. It is as white as silver, has great lustre, and is a conductor of electricity. The property of welding—which belongs to iron and platina at a white heat only—is possessed by this substance at common temperatures. It fuses at a temperature about 200°, and evaporates at a strong red heat. Its specific gravity is 0·972, and is consequently lighter than water. In oxygen gas it produces a white flame, and sends forth bright sparks occasioning a very beautiful effect. In oxymuriatic acid gas, it burns vividly, with numerous scintillations of a bright red colour. In the quantity of one-fortieth, it renders mercury a *fixed solid* of the colour of silver, and forms an alloy with tin. When thrown upon water it effervesces violently, but does not inflame. It swims on the surface, gradually diminishes with great agitation, and renders the water a solution of soda. It acts upon most substances in a manner similar to potassium; but with less energy: it tarnishes in the air, but more slowly; it then absorbs oxygen. Like potassium, it is best preserved under naphtha. It differs from potassium, however, in remaining soft and malleable at the freezing point, and in having a greater specific gravity. At the temperature of 194°, it becomes fluid, and it also requires a higher temperature than potassium to volatilize it, it being to remain fixed at a heat at which plate-glass is melted.

It has been questioned by some, whether Potassium and Sodium, or the bases of potash and soda, should be arranged among the class of metals. That they are entitled to be ranked in this class appears in that they agree with metals in their being opaque—in their having the metallic lustre—in their being susceptible of malleability—in their conducting powers as to heat and electricity, and in their qualities of chemical combination. Even their low specific gravity does not appear a sufficient reason for making them

a new class of substances; for among the metals there are remarkable differences in this respect; platina being nearly four times as heavy as tellurium; and tellurium is not much more than six times as heavy as the basis of soda, or sodium. So that there can be no question that those new bodies ought to belong to the class of metallic substances; and the circumstance that they differ so much from other metals in their peculiar properties, is just another instance and evidence, in addition to those we already know, of the infinite *variety* which the Creator has introduced throughout every part of his creation.

The researches of modern chemists have led to some surprising results, among which are the discoveries of the metals which form the bases of lime, flint, and common clay. From the latter, the new metal called Aluminium has been formed. This metal is an extensive constituent of the inorganic world. It enters largely into clays and marls, and few rocks, understanding that term in the geological sense, are without it. Aluminium may be prepared by decomposing chloride of aluminium by means of potassium or sodium, and washing away the resulting alkaline chloride with water; in which liquid aluminium is unalterable at any temperature.

Until lately Aluminium had only been prepared in small quantities, and was but little studied; within the last year (1855), however, a process for manufacturing it on the large scale has been instituted, under the auspices of the Emperor of the French, by M. St. Claire Deville. Several bars of Aluminium have now been produced, and some notions formerly entertained respecting it have been discovered to be erroneous. For example: the impression was formerly entertained that Aluminium could scarcely be fused by the strongest furnace heats, whereas it is now found to melt with almost the facility of silver. Formerly, too, it was believed that Aluminium would tarnish by exposure to watery vapour and general atmospheric influences; that notion, too, has been found incorrect.

The method of producing Aluminium by St. Claire Deville is essentially the method formerly known—namely, by the action of sodium on chloride of aluminium. Potassium would have equally answered the purpose, had considerations of economy not interfered with its extensive application. Hitherto no method has been devised for materially lessening the cost of the production of po-

tassium; sodium is, however, now procurable at Paris for about ten shillings per pound avoirdupois. It is generated, in point of fact, with scarcely greater difficulty than zinc. It is owing to the extreme cheapness of sodium more than any other reason that M. St. Claire Deville has been enabled to obtain Aluminium in comparatively large quantities, for his actual process of manufacture involves no new principle. He at present employs iron tubes in which to effect the decomposition of chloride of aluminium by sodium; but this is a contrivance which he informs us leaves something to be desired.

The science of chemistry is still in progress, and is making rapid advances. Among its recent improvements may be noticed the discovery of Dobreiner in relation to the power of platinum in effecting the combination of oxygen and hydrogen—the researches of Faraday, in the course of which many of the gases have been reduced to a liquid form—the discovery of new compounds of carbon and hydrogen, and the singular fact which they exhibit of different combinations being established in the same proportions—the discovery of the real bases of silex and zircon, as mentioned above, and that of the new principle *brome*—with many other improvements and discoveries too numerous for detail. Our knowledge of the nature and properties of light and electricity has of late years been considerably enlarged, and the new science of electro-magnetism, which is intimately connected with chemistry, must have a tendency to accelerate its progress, and no limits can be placed to the extent of its investigations.

Such is a brief description of the principal elementary substances, which, in a thousand diversified forms, pervade the system of nature, and produce all that variety which we behold in the atmosphere, the waters, the earth, and the various processes of the arts. It is probable that some of these substances are compounds, though they have not yet been decomposed. Yea, it is possible, and not at all improbable, that there are but two, or at most three clementary substances in nature, the various modifications of which produce all the beauties and sublimities in the universe. Perhaps caloric, oxygen, and hydrogen, may ultimately be found to constitute all the elementary principles of nature.—

Without prosecuting this subject further, I shall conclude this article with a few cursory reflections, tending to illustrate its connection with religion.

The remarks which I have already thrown out in reference to Natural Philosophy will equally apply to the science of Chemistry; and therefore do not require to be repeated. In addition to these, the following observations may be stated:—

(1.) This science displays, in a striking point of view, the wisdom and goodness of God, in *producing, by the most simple means, the most astonishing and benevolent effects.* All the varied phenomena we perceive throughout the whole system of sublunary nature are produced by a combination of six or seven simple substances. I formerly adverted to the infinite variety which exists in the vegetable kingdom. About 56,000 different species of plants have already been discovered by botanists. All these, from the humble shrub to the cedar of Lebanon, which adorn the surface of the globe, in every clime, with such a diversity of forms, shades, and colours, are the result of the combinations of "four or five natural substances—caloric, light, water, air, and carbon." "When we consider," says Mr. Parkes, "that the many thousand tribes of vegetables are not only all formed from a few simple substances, but that they all enjoy the same sun, vegetate in the same medium, and are supplied with the same nutriment, we cannot but be struck with the rich economy of nature, and are almost induced to doubt the evidence of those senses with which the God of nature has furnished us. That it should be possible so to modify and intermingle a few simple substances, and thence produce all the variety of form, colour, odour, etc., which is observable in the different families of vegetables, is a phenomenon too astonishing for our comprehension. Nothing short of Omnipotence could have provided such a paradise for man."[1]

> "Soft roll your incense, herbs and fruits and flowers,
> In mingled clouds, to Him whose sun exalts,
> Whose breath perfumes you, and whose pencil paints."
>
> THOMSON.

What an admirable view is here opened up of the economy of Divine wisdom, and of the beneficent care which has been taken to secure the comfort and happiness of every living creature; and

[1] Chemical Catechism, chap. ix.

how ungrateful a disposition must it indicate in rational beings to overlook such benevolent arrangements! It is highly probable, that, in all the other worlds dispersed throughout the universe, an infinite diversity of scenery exists, and that no one globe or system exactly resembles another; and yet it is probable, that the primary elements of matter, or the few *simple substances* of which our world is composed, may be of the same nature as those which form the constituent parts of every other system; and may give birth to all the variety which exists throughout the wide extent of creation, and to all the changes and revolutions through which the different systems may pass, during every period of infinite duration.

(2.) From this science we have every reason to conclude that matter is indestructible. In the various changes that take place in material substances, the particles of matter are not destroyed, but only assume new forms, and enter into new combinations. When a piece of wood, for example, is burned to ashes, none of its principles are destroyed; the elementary substances of which it was composed are only separated from one another, and formed into new compounds. Carbon, as already stated, appears to be indestructible by age, and to preserve its essential properties, in every mode of its existence. That Being, indeed, who created matter at first, may reduce it to nothing when he pleases; but it is highly improbable that His power will ever be interposed to produce this effect: or that any particle of matter which now exists, will ever be annihilated, into whatever new or varied combinations it may enter. When any particular world, or assemblage of material existence, has remained in it's original state for a certain period of duration, and accomplished all the ends it was intended to subserve in that state, the materials of which it is composed, will, in all probability, be employed for erecting a new system, and establishing a new series of events, in which new scenes, and new beauties and sublimities will arise from new and varied combinations. For the Creator does nothing in vain. But to annihilate, and again to create, would be operating in vain; and we uniformly find, that in all the arrangements of Deity, in the present state of things, Nature is frugal and economical in all our proceedings; so that there is no process, when thoroughly investigated, that appears unnecessary or superfluous.

From the fact, that matter appears to be indestructible, we may learn, that the Creator, with the self-same materials which now

exist around us, may, after the general conflagration, new-model and arrange the globe we inhabit, so as to make a more glorious world to arise out of its ashes; purified from those physical evils which now exist; and fitted for the accommodation either of renovated men, or of other pure intelligencies. From the same fact, combined with the consideration of the infinite diversity of effects which the simple substances of nature are capable of producing, we may be enabled to form a conception of the ease with which the Creator may new-model our bodies, after they have been dissolved in the dust; and how, from the same original atoms, he may construct and adorn them with more glorious forms, and more delightful and exquisite senses than they now possess.

In short, the rapid progress which chemical science is now making, promises, ere long, to introduce improvements among the human race, which will expand their views of the agency of God, counteract many physical evils, and promote to an extent which has never yet been experienced, their social and domestic enjoyment. The late discoveries of Chemistry tend to convince us, that the properties and powers of natural substances are only beginning to be discovered. Who could have imagined, a century ago, that an invisible substance is contained in a piece of coal, capable of producing the most beautiful and splendid illumination—that this substance may be conveyed in a few moments, through pipes of several miles in length—and that a city, containing several hundred thousands of inhabitants, may be instantly lighted up by it, without the aid of either wax, oil, or tallow? Who could have imagined that one of the ingredients of the air we breathe is the principle of combustion—that a rod of iron may be made to burn in it with a brilliancy that dazzles the eyes—that a piece of charcoal may be made to burn with a white and splendid light, which is inferior only to the solar rays—and that the *diamond* is nothing more than *carbon* in a crystallized state, and differs only in a slight degree from a bit of common charcoal? Who could have surmised, that a substance would be discovered, of such a degree of levity, as would have power sufficient to buoy up a number of men to the upper parts of the atmosphere, and enable them to swim, in safety, above the region of the clouds? These are only specimens of still more brilliant discoveries which will doubtless be brought to light by the researches of future generations. We have reason to believe, that the investigations of this science will in due time enable

us to counteract most of the diseases incident to the human frame; and to prevent many of those fatal accidents to which mankind are now exposed. DAVY'S *safety lamp* has already preserved many individuals from destruction, when working in coal mines; and thousands, in after ages, will be indebted to this discovery, for security from the dreadful explosions of hydrogen gas. And, we trust, that the period is not far distant, when specific antidotes to the diseases peculiar to the different trades and occupations in which mankind are employed will be discovered; and the health and vigour of the mass of society be preserved unimpaired, amidst all the processes in which they may be engaged.

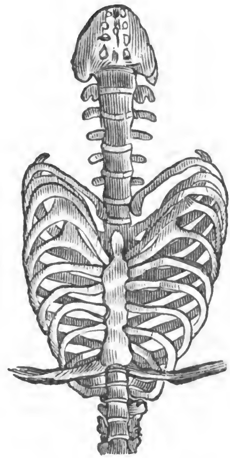
In fine, the rapid progress of chemical discovery carries forward our views to a period, when man, having thoroughly explored the powers of nature, and subjected them in some measure to his control, will be enabled to ward off most of those physical evils with which he is now annoyed, and to raise himself, in some degree, to the dignity and happiness he enjoyed before moral evil had shed its baleful influence on our terrestrial system. Such a period corresponds to many of the descriptions contained in the Sacred Oracles of the millennial state of the Church; when social, domestic, moral, and intellectual improvement shall be carried to the utmost perfection which our sublunary station will permit: when wars shall cease; when the knowledge of Jehovah shall cover the earth; when every man shall sit under his own vine and fig-tree, with none to make him afraid; and when there shall be nothing to hurt nor destroy throughout the Church of the living God. And therefore, we ought to consider the various discoveries and improvements now going forward in this, and other departments of science, as preparing the way for the introduction of this long-expected and auspicious era.

Anatomy and Physiology.

The general object of both these sciences is, to investigate and describe the structure and economy of the animal frame.—*Anatomy* dissects *dead* bodies; *Physiology* investigates the functions of those that are *living*. The former examines the fluids, muscles, viscera, and all the other parts of the human body, in a state of *rest;* the latter considers them in a state of *action*.

The parts of the human body have been distinguished into two

different kinds—solids and fluids. The solid parts are, *bones, cartilages, ligaments, muscles, tendons, membranes, nerves, arteries, veins, hair, nails,* and *ducts,* or fine tubular vessels of various kinds. Of these solid parts, the following compound organs consist: the *brain* and *cerebellum,* the *lungs,* the *heart,* the *stomach,* the *liver,* the *spleen,* the *pancreas,* the *glands,* the *kidneys,* the *intestines,* the *mesentery,* the *larnyx,* and the organs of sense—the *eyes, ears, nose,* and *tongue.* The fluid parts are, the *saliva,* or spittle, *phlegm, serum,* the *chyle, blood, bile, milk, lympha, urine,* the *pancreatic juice,* and the *aqueous humour* of the eyes. The human body is divided into three great cavities—the *head;* the *thorax* or breast; and the *abdomen,* or belly. The *head* is formed of the bones of the cranium, and encloses the brain and cerebellum. The *thorax* is composed of the vertebræ of the back, the sternum, and true ribs; and contains the *heart,* the *pericardium,* the *breasts,* and the *lungs.* The *abdomen* is separated from the thorax by means of the *diaphragm,* which is a fleshy and membranous substance, composed for the most part of muscular fibres. This cavity is formed by the lumbar vertebræ, the os sacrum, the ossa innominata, the false ribs, the peritonæum, and a variety of muscles. It encloses the stomach, intestines, omentum, or caul, the liver, pancreas, spleen, kidneys, and urinary bladder.—Without attempting any technical description of these different parts which could convey no accurate ideas to a general reader, I shall merely state two or three facts in relation to the system of bones, muscles, and blood-vessels, as *specimens* of the wonderful structure of our bodily frame.



PELVIS, SPINE, AND CHEST.

The Bones.

The Bones may be regarded as the propwork or scaffolding on

which the human body is constructed. They bear the same relation to the animal system, as the woodwork to a building. They give shape and firmness to the body; they support its various parts, and prevent it from sinking by its own weight; they serve as levers for the muscles to act upon, and to defend the brain, the heart, the lungs, and other vital parts from external injury. Of the bones, some are *hollow*, and filled with marrow; others are *solid* throughout; some are very *small;* others very *large;* some are *round*, and others *flat;* some are *plane*, and others *convex* or *concave;*—and all these several forms are requisite for the situations they occupy, and the respective functions they have to perform.—The *spine*, or back-bone, consists of twenty-four vertebræ, or small bones, connected together by cartilages, articulations, and ligaments; of which seven belong to the neck, twelve to the back, and five to the loins. In the centre of each vertebræ there is a hole for the lodgment and continuation of the spinal marrow, which extends from the brain to the rump. From these vertebræ the arched bones called *ribs* proceed; and seven of them join the breastbone on each side, where they terminate in cartilages, and form the cavity of the thorax or chest. The five lower ribs, with a number of muscles, form the cavity of the abdomen, as above stated. The spine is one of the most admirable mechanical contrivances in the human frame. Had it consisted of only three or four bones, or had the holes in each bone not exactly corresponded, and fitted into each other, the spinal marrow would have been bruised, and life endangered at every bending of the body. The skull is composed of ten bones, and about fifty-one are reckoned to belong to the face, the orbits of the eyes, and the jaws in which the teeth are fixed. There are seldom more than sixteen teeth in each jaw, or thirty-two in all.—The number of

THE SHOULDER JOINT.

bones in a human body is generally estimated at about 245; of which there are reckoned, in the skull, head, and face, sixty-one; in the trunk, sixty-four; in the arms and hands, sixty; and in the legs and feet, sixty. The bones are provided with *ligaments*, or hinges, which bind and fasten them together, and prevent them from being displaced by any violent motion; and, that the ligaments may work smoothly into one another, the joints are separated by *cartilages*, or gristles, and provided with a gland for the secretion of oil, or *mucus*, which is constantly exuding into the joints; so that every requisite is provided by our Benevolent Creator, to prevent pain, and to promote facility of motion. "In considering the joints," says Dr. Paley, "there is nothing, perhaps, which ought to move our gratitude more than the reflection, *how well they wear*. A limb shall swing upon its hinge, or play in its socket, many hundred times in an hour, for sixty years together, without diminution of agility; which is a long time for anything to last, for any thing so much worked as the joints are."

The Muscular System.

A *muscle* is a bundle of fleshy, and sometimes of tendinous fibres. The fleshy fibres compose the body of the muscle; and the tendinous fibres the extremities. Some muscles are long and round; some plain and circular; some have *spiral*, and some have *straight* fibres. Some are double, having a tendon running through the body from head to tail; some have two or more tendinous branches running through, with various rows and orders of fibres.

The following figures (fig. 29, 30, etc.) exhibit a representation of the forms of some of the muscles. Fig. 29, represents a broad muscle whose fibres run *straight*,—Fig. 30, a species of muscle whose fibres lie divaricated, or converge from their beginning to a narrow tendon,—Fig. 31, a double muscle which consists of a tendon running through its body from head to tail and a row of fibres on each side. Fig. 32, represents a muscle still more double, having two or more tendinous branches running through them, with various rows and orders of fibres.—The substance of the muscles is of a peculiar nature, arranged in fibres of extreme delicacy. It is distinguished from every other texture in the human frame by an innate power of contraction. On examining

it with microscopes of great magnifying power it is found to be composed of filaments so fine as the *one-forty thousandth* part of an

Fig. 29.

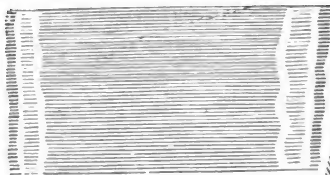


Fig. 30.

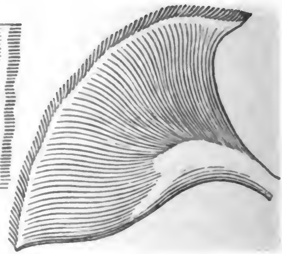


Fig. 31.

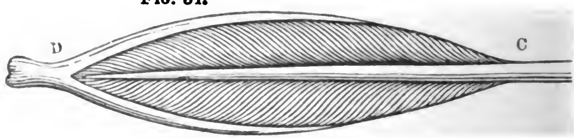
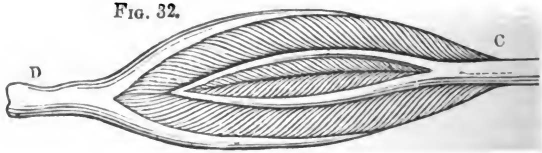


Fig. 32.



inch in diameter. These filaments collected together form *fibres*, which are perceptible in boiled flesh. A collection of these fibres form a bundle, and these bundles collectively constitute a *muscle*. The muscular fibres are every where penetrated by numerous blood vessels and nerves; indeed, no part of the body except perhaps the organs of sense, is so abundantly supplied with these vessels; and there is reason to believe that every filament, however fine, is provided with the ultimate branch of an artery, vein, and nerve.—It is found, that the more fibres there are in the body of the muscle, the stronger is the action of such a muscle; and therefore the strongest muscles are always placed in those parts of the system where the greatest power and force are required. The

peculiar property of muscular tissue is *vital*, and consists in the power of diminishing its length, or shortening on the application of stimulus. All the motions of the body are performed by means of it, and without its incessant action, neither respiration, digestion, nor the circulation of the fluids would be carried on for a moment.

All the varieties of muscles now alluded to, and multitudes of others, are essentially requisite for the respective offices they have to perform in the animal system. The muscles constitute the fleshy part of the human body, and give it that varied and beautiful form we observe over all its surface. But their principal design is to serve as the *organs of motion*. They are inserted, by strong tendinous extremities, into the different bones of which the skeleton is composed; and by their contraction and distention, give rise to all the movements of the body. The muscles, therefore, may be considered as so many cords attached to the bones; and the Author of Nature has fixed them according to the most perfect principles of mechanism, so as to produce the fittest motions in the parts for the movements of which they are intended.

One of the most wonderful properties of the muscles is the *extraordinary force they exert*, although composed of such slender threads, or fibres. The following facts in relation to this point are demonstrated by the celebrated *Borelli*, in his work, '*De Motu Animalium*.' When a man lifts up with his teeth a weight of 200 pounds with a rope fastened to the jaw-teeth, the muscles named *Temporalis* and *Masseter*, with which people chew, and which perform this work, exert a force of above 15,000 pounds weight. If any one hanging his arm directly downwards lifts a weight of twenty pounds, with the third or last joint of his thumb, the muscle which bends the thumb, and bears that weight, exerts a force of about *three thousand pounds*. When a man, standing upon his feet, leaps or springs upwards to the height of two feet, if the weight of such a man be 150 pounds, the muscles employed in that action will exert a force 2000 times greater; that is to say, a force of about *three hundred thousand pounds*. The heart, at each pulse or contraction, by which it protudes the blood out of the arteries into the veins, exerts a force of above *a hundred thousand pounds*. Who can contemplate this amazing strength of the muscular system without admiration of the power and wisdom of the Creator, who has endued a bundle of threads, each of them

smaller than a hair, with such an astonishing degree of mechanical force! There have been reckoned about 446 muscles in the human body, which have been dissected and distinctly described; every one of which is essential to the performance of some one motion or other, which contributes to our ease and enjoyment; and, in most instances, a great number of them are required to perform the different functions at the same time. It has been calculated, that about *a hundred muscles* are employed every time we breathe. —"Breathing with ease," says Dr. Paley, "is a blessing of every moment; yet, of all others, it is that which we possess with the least consciousness. A man in an asthma is the only man who knows how to estimate it."

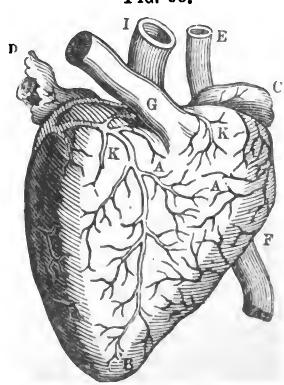
The Heart and Blood Vessels.

The heart is a hollow muscular organ of a conical shape, and consists of four distinct cavities. The two largest are called *ventricles*, and the two smallest *auricles*. The ventricles *send out* the blood to the arteries; the auricles *receive* it from the veins. The heart is enclosed in the *pericardium*, a membranous bag, which contains a quantity of water. This water lubricates the heart and facilitates all its motions. The heart is the general reservoir of the blood. When the heart contracts, the blood is propelled from the *right ventricle* into the lungs, through the pulmonary arteries, which, like all the other arteries, are furnished with *valves* that play easily forward, but admit not the blood to return toward the heart. The blood, after circulating through the lungs, and having there been re-vivified by coming in contact with the air, and imbibing a portion of its oxygen, and giving off the deleterious carbon with which it has become charged, in the course of its circulation through the body—returns into the *left auricle* of the heart by the pulmonary vein, which, in its turn, pours its contents into the *left ventricle*, which immediately contracts, and drives the blood into the *aorta*, a large artery which sends off branches to supply the head and arms; after which, it descends along the side of the back-bone, and detaches numerous ramifications to nourish the bowels and inferior extremities. After serving the most remote extremities of the body, carrying with it life and heat to every member, it is returned by another set of vessels called *veins*, which are undoubtedly a continuation of the arteries, which, in

their return to the heart, gradually unite into larger branches, till the whole terminate in one great trunk called the *vena cava,* which discharges itself into the *right auricle* of the heart, and completes the circulation.

The motion of the blood is chiefly owing to the action of the heart, which contracts *with great force* in the following manner:—The auricles both contract at the same instant, forcing the blood which is received from the lungs and the general circulation into the ventricles; these then contract at the same moment, the right one sending the blood through the *lungs*, the left one through the *aorta;* which action is constant so long as life continues. The ventricles contract more suddenly and powerfully than the auricles, and they are three times as long in dilating or expanding as contracting. When the ventricles contract, the *apex,* or point of the heart, rises up and strikes against the left wall of the chest, between the sixth and seventh ribs; and this can be felt by placing the hand on the left side. The left ventricle has much thicker and stronger walls than the right, because it has a greater distance to throw the blood; but the right ventricle will hold more than the left, because the venous system is more capacious than the arterial. —The velocity of the blood in the arterial system grows slower in proportion to its distance from the heart, while that in the veins is accelerated the nearer it approaches the heart.[1]

Fig. 33.



What has been now stated respecting the heart and its vessels may perhaps be somewhat illus trated by fig. 33, where one view of the heart is represented. It will be perceived that at the upper part A it is thick and broad, but at the lower part B much more slender; its shape is somewhat similar to that of an inverted blunt pyramid. It is fastened and suspended by its veins and arteries E F G H I. E is the vena cava, or hollow vein by which the blood descends; G is the pulmonary artery, through which it passes out of this ven-

[1] Lee's 'Human Physiology.'

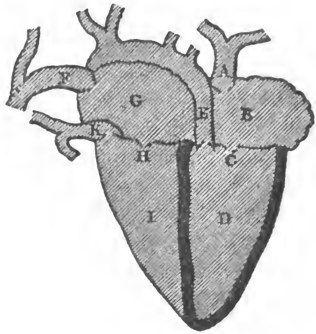
tricle into the lungs; and H is the pulmonary vein from which the same blood returns from the lungs into the left ventricle of the heart, out of which it is carried by the aorta, or great artery I, to all the parts of the body. C is the right auricle of the heart into which the blood passes from E and F before it falls into the right ventricle. D is the left auricle which performs the same function to the left ventricle. K K are the coronary arteries and the coronary veins, which feed the heart and provide it with blood.[1]

Here it may not be improper to remark, that the stream of blood descending from the vena cava at E, meeting with another stream ascending at F, seems to threaten the apparent danger of these two currents rushing against each other, preventing the regular circulation, and thereby endangering life itself. To prevent so dangerous an occurrence, there is placed between the two veins E and F a *protuberance*, composed of the fat that lies under, against which the blood descending from E runs or strikes, and by that means the course of it is turned to the right auricle of the heart, while the blood ascending from F is, by this protuberance, covered and secured against the opposite course of the descending blood, and thus is obliged to turn its course aside to the ventricle of the heart.—Here we have a striking proof of the admirable wisdom and design of the Creator, in the most minute arrangements he has made in the construction of the human frame, and likewise of his goodness in providing against every accident that might endanger the system. For there must have been an express *design* in making these arrangements, as not only our comforts but our very existence depend upon them.

The following figure represents a *section* of the heart in which the auricles and ventricles, and the vessels connected with them are more distinctly seen than in the preceding figure:—

[1] The circulation of the blood may be seen in certain animals by means of the microscope. The fine web of a frog's foot is generally used for this purpose, as it is transparent, and the veins and arteries are seen through the skin. The tail of the water-newt, a tadpole, or a small fish, will answer the same purpose. When these animals are properly placed, and their webs stretched under a good compound microscope, it is astonishing and highly gratifying to perceive the ramifications of the arteries and veins, and the *velocity* with which the streams of blood seem to flow in every direction—a circumstance almost incredible, if it were not demonstrated by ocular inspection.

Fig. 34.

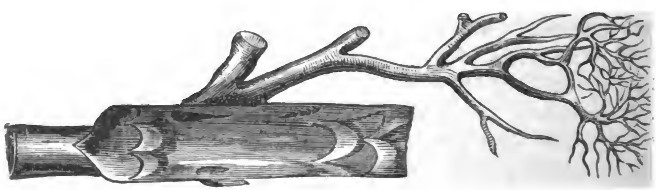


" A, pulmonary vein entering the left auricle, into which it pours pure blood. B left auricle. C left auriculo ventricular opening, through which the pure blood is conveyed from the left auricle to the left ventricle. D left ventricle, very muscular, which propels the nourishing blood through E, the aorta and its ramifications. When the blood has passed through these arteries, it is returned by the veins which terminate in F, the vena cava, which pours the blood, now deprived of its invigorating principles, into G, the right auricle. The blood is thence conveyed through H, the right ariculo ventricular opening, into I, the right ventricle, which, contracting on this impure blood, sends it through K, the pulmonary arteries, which convey it to the lungs, situated in the chest on either side of the heart, for purification; when it has undergone this process, it is returned to where we set out at A."

Each ventricle of the heart contains about one ounce, or two table spoonfuls of blood, and this is changed more than sixty times every minute. The heart contracts 4000 times every hour, and consequently there passes through it 250 pounds of blood in one hour, or 6000 pounds every twenty-four hours. And if the mass of blood in a human body be reckoned at an average at twenty-five pounds, it will follow, that *the whole mass of blood passes through the heart*, and consequently through the thousands of ramifications of the veins and arteries, *ten times every hour*, or once every six minutes. The heart beats more than one hundred thousand times in twenty-four hours, and thus continues to beat, in many instances, for eighty or 100 years, although at every stroke it has a great resistance to overcome. What other machine, so complicated, and so delicate, could last so long! And yet it is composed of nothing but flesh, and other substances of the most flabby texture. It has been often said with respect to those who venture their lives in ships, that there is only a *plank* between

them and destruction; but in the delicate and complicated machine of the human frame, and especially in the heart and arteries and veins, there is only a membrane, or a small cord or valve, that prevents the complete derangement of the animal system, and the entire cessation of the functions of life. It may therefore be truly said, in the language of inspiration, that "Man is fearfully and wonderfully made."—The *force* with which the blood is thrown from the heart is variously estimated. Some have thought that the contraction must overcome the whole pressure of the air upon the body, which is equal to above thirty thousand pounds. We may acquire a rude idea of the force with which the blood is impelled from the heart, by considering the velocity with which water issues from a syringe or from the pipe of a fire-engine. Could we behold these rapid motions incessantly going on within us, it would overpower our minds with astonishment and even with terror. We should be apt to feel alarmed on making the smallest exertion, lest the parts of this delicate machine should be broken or deranged, and its functions interrupted or destroyed.

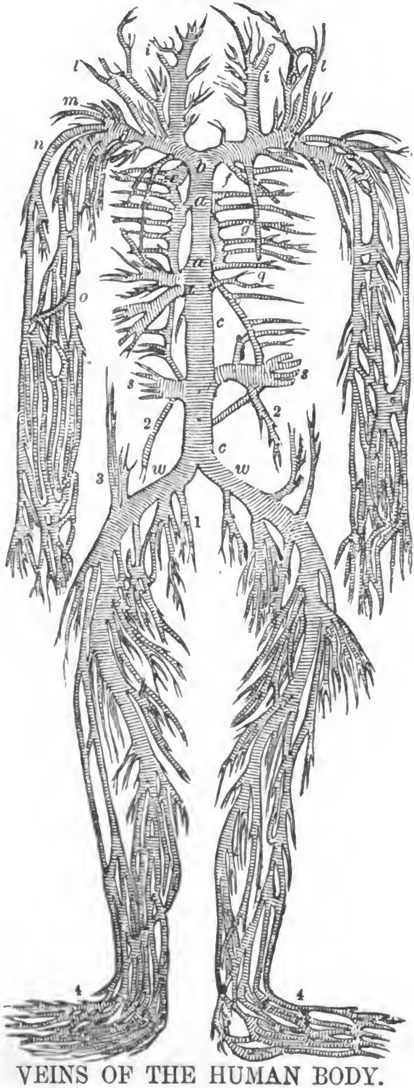
The arteries into which the blood is forced branch in every direction through the body like the roots and branches of a tree,



SECTION OF AN ARTERY.

running through the substance of the bones, and every part of the animal frame, till they are lost in such fine tubes as to be wholly invisible. The arteries in general have corresponding veins placed near them. The trunks of the veins, and of almost all the arteries, are deeply seated, but the smaller veins are every where thickly distributed on the surface of the body immediately below the skin. By this structure a passage is provided for the blood on the surface of the body, where the internal veins are so compressed by the action of the muscles as not easily to transmit their contents.

FIG. 35.



VEINS OF THE HUMAN BODY.

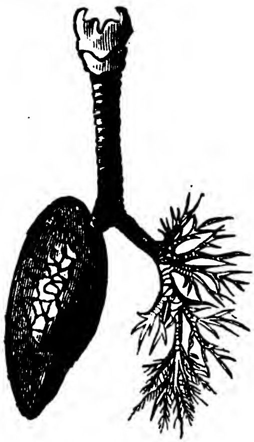
—In the parts where the arteries are lost to the sight, the veins take their rise, and in their commencement are also imperceptible. They have been divided into two classes—those which return the blood conveyed by the pulmonary to the heart, and those which return that of the aorta. Besides the blood which the lungs receive in common with the other parts of the body, they also receive all that is transmitted by the pulmonary artery. This, after being distributed through the substance of the lungs, is returned by veins that at last unite into four trunks, which are inserted into the posterior auricle of the heart. FIGURE 35, page 499, shows the trunks and branches into which the veins of the body are ramified:—

a a, Vena cava; *b*, descending trunk of the cava; *c*, the ascending trunk of the cava; *d d*, subclavian veins; *e*, vena azygos; *f*, intercostal veins; *g*, mammary veins; *i i*, internal jugulars; *l l*, external jugulars; *m*, right auxiliary vein; *n*, cephalic vein; *o*, basilic; *q*, phrenic; *s s*, emulgents; *w w*, iliac branches; *x*, internal iliacs;—1, vena sacra; 2, spermatic veins; 3, epigastric; 4, saphena.

These are the names of only a few of the numberless ramifications of the venous system. The arteries are as numerous, and present a similar system of ramifications, extending throughout the whole texture of the human frame. They show us what a wonderfully complicated and exquisite machine the human body is, and on the action of how many parts and functions our life and happiness depend, especially when we consider that this system of veins and arteries is interwoven with an infinity of nerves, and hundreds of bones, muscles, ligaments, lacteals, lymphatics, and other parts essential to the animal system. Yet, amidst all this vast multiplicity of parts, each is so correctly fashioned, and all so exactly arranged, that the whole machine moves on in perfect harmony when not deranged by external violence—each part assisting the operation of another, and all conspiring to the preservation of the whole—demonstrating that the Framer of this admirable machinery is "the only Wise God; wonderful in counsel and excellent in working," and whose grand design in all his arrangements is to promote the comfort and happiness of his creatures.

Respiration.

The organs of respiration are the *lungs*. They are divided into five lobes; three of which lie on the right, and two on the left side of the thorax. The substance of the lungs is chiefly composed of infinite ramifications of the trachea, or windpipe, which, after gradually becoming more and more minute, terminate in little cells or vesicles, which have a free communication with one another. At each inspiration, these pipes and cells are filled with air, which is again discharged by expiration. In this manner, a circulation of air, which is necessary to the existence of men and other animals, is constantly kept up as long as life remains. The air-cells of the lungs open into the windpipe, by which they communicate with the external atmosphere. The whole internal structure of the lungs is lined by a transparent membrane, estimated at only the thousandth part of an inch in thickness; but whose surface from its various convolutions, measures fifteen square feet, which is equal to the external surface of the body. On this thin and extensive membrane innumerable veins and arteries are distributed, some of them finer than hairs; and through these vessels all the blood of the system is successively propelled, by a most curious and admirable mechanism. It has been computed that the lungs on an average contain about 280 cubic inches, or about five English quarts of air. At each inspiration, about forty cubic inches of air are received into the lungs, and the same quantity discharged at each expiration. On the supposition that twenty respirations take place in a minute, it will follow that, in one minute, we inhale 800 cubic inches; in an hour 48,000; and in a day one million one hundred and fifty-two thousand cubic inches—a quan-



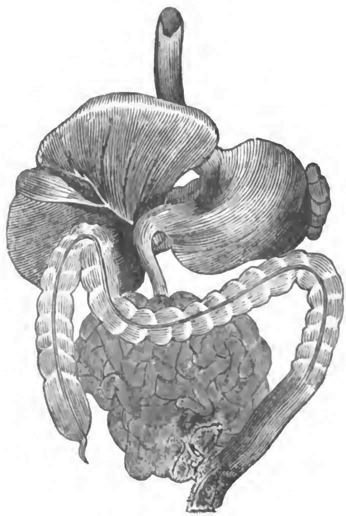
THE LUNGS.

tity which would fill seventy-seven wine hogsheads, and would weigh fifty-three pounds Troy. By means of this function, a vast body of air is daily brought into contact with the mass of blood, and communicates to it its vivifying influence; and therefore it is of the utmost importance to health that the air, of which we breathe so considerable a quantity, should be pure and uncontaminated with effluvia.

In respiration the air meets the blood in the lungs, and part of the oxygen of the atmosphere is absorbed by it, and imparts to it its red colour. Part of the oxygen is also converted into carbonic acid by combining with carbon, or charcoal, in the lungs. In every instance air which has been respired loses a part of its oxygen; the quantity varies at different times, according to the operation of certain external agents. It is reckoned that, upon an average, a man under ordinary circumstances consumes 45,000 cubic inches, or 15,500 grains of oxygen, in twenty-four hours. A quantity of carbonic acid is at the same time produced, which is generally somewhat less than the oxygen consumed, and may be reckoned at 40,000 cubic inches in twenty-four hours. It has been found that in the human species different individuals consume different quantities of oxygen, and of course return different quantities of carbonic acid. The breath expired has been shown to contain from six to eight per cent. of carbonic acid. It has been found that the nitrogen of the air inspired is sometimes returned in full volume, and sometimes is partially retained and disappears. On the whole, as respiration is one of the most important functions of animal life, on which our very existence depends, so we may plainly perceive, from the above and other circumstances, with what a variety of other functions it is connected, and on what a variety of minute and invisible processes its operations depend.

Digestion.

This process is performed by the *stomach*, which is a membranous and muscular bag, furnished with two orifices. By the one, it has a communication with the gullet, and by the other, with the bowels. The food, after being moistened by the saliva, is received into the stomach, where it is still further di-



LIVER, STOMACH, AND BOWELS.

luted, by the *gastric juice*, which has the power of dissolving every kind of animal and vegetable substance. Part of it is afterwards absorbed by the *lymphatic* and *lacteal* vessels, and carried into the circulating system, and converted into blood for supplying that nourishment which the perpetual waste of our bodies demands. All growth, nay, life itself, depends upon a continual renewal and decay of the body. The gastric juice act only on dead matter, which explains the fact of the destruction or distillation of the food taken into the stomach, and of the body itself after death.

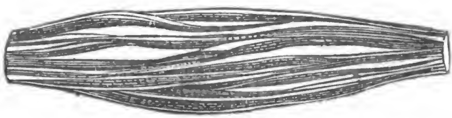
Perspiration.

Perspiration is the evacuation of the juices of the body through the pores of the skin. It has been calculated that there are above *three hundred thousand millions of pores* in the glands of the skin which covers the body of a middle-sized man. Through these pores more than one-half of what we eat and drink passes off by *insensible* perspiration. If we consume eight pounds of food in a day, five pounds of it are insensibly discharged by perspiration. During a night of seven hours' sleep, we perspire about forty ounces, or two pounds and a half. At an average, we may estimate the discharge from the surface of the body, by sensible and insensible perspiration, at from half an ounce to four ounces an hour. This is a most wonderful part of the animal economy, and is absolutely necessary to our health, and even to our very exist ence. When *partially* obstructed, colds, rheumatisms, fevers, and

other inflammatory disorders are produced; and were it completely obstructed, the vital functions would be clogged and impeded in their movements, and death would inevitably ensue.

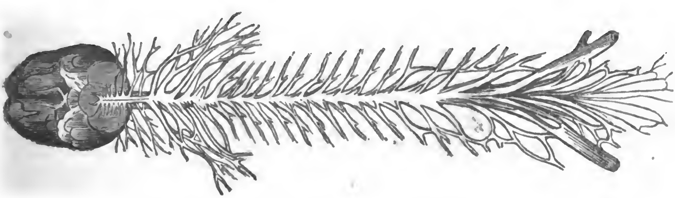
Sensation.

The *nerves* are generally considered as the instruments of sensation. They are soft white cords which proceed from the brain



FIBRES COMPOSING THE NERVES.

and spinal marrow. They come forth originally by pairs. Ten pairs proceed from the medullary substance of the brain, which are distributed to all parts of the head and neck. Thirty pairs proceed from the spinal marrow, through the vertebræ, to all the



THE BRAIN AND NERVES.

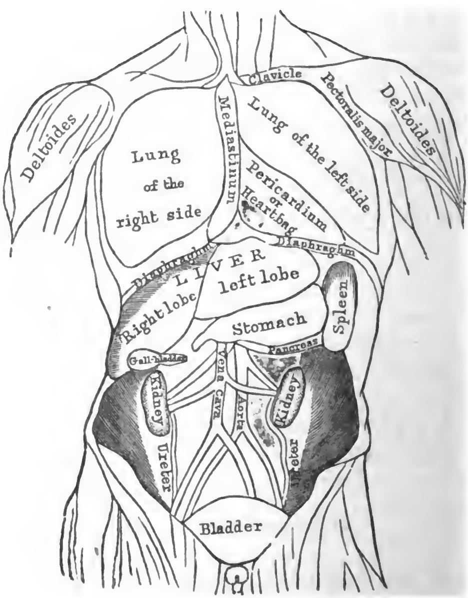
other parts of the body; being forty in all. These nerves, the ramifications of which are infinitely various and minute, are distributed upon the heart, lungs, blood-vessels, bowels, and muscles, till they terminate on the skin or external covering of the body. Impressions of external objects are received on the brain from the

adjacent organs of sense, and the brain exercises its commands over the muscles and limbs by means of the nerves.

The Thorax and Abdomen.

The following representation (fig. 36,) is intended to present to the view the form and relative positions of the parts of the human body contained in the thorax and abdomen; particularly the lungs, the heart, diaphragm, the liver, the gall-bladder, and various other parts, so that the reader may be enabled to appreciate them on a single inspection.

FIG. 36.



THE THORAX AND ABDOMEN.

Without prosecuting these imperfect descriptions further, I shall conclude this very hasty sketch with the following summary of the

parts of the body, in the words of Bonnet.—"The *bones*, by their joints and solidity, form the foundation of this fine machine: the *ligaments* are strings which unite the parts together: the *muscles* are fleshy substances, which act as elastic springs to put them in motion: the *nerves*, which are dispersed over the whole body, connect all the parts together: the *arteries* and *veins*, like rivulets, convey life and health throughout: the *heart*, placed in the centre, is the focus where the blood collects, or the acting power by means of which it circulates and is preserved: the *lungs*, by means of another power draw in the external air and expel hurtful vapours: the *stomach* and intestines are the magazines where every thing that is required for the daily supply is prepared: the *brain*, that seat of the soul, is formed in a manner suitable to the dignity of its inhabitant: the *senses*, which are the soul's ministers, warn it of all that is necessary either for its pleasure or use.[1] Adorable Creator! with what wonderful art hast thou formed us! Though the heavens did not exist to proclaim thy glory—though there were no created being upon earth but myself, my own body might suffice to convince me that thou art a God of unlimited power and infinite goodness."

This subject suggests a variety of moral and religious reflections, but the limits to which I am confined will permit me to state only the following:—

(1.) The economy of the human frame, when seriously contemplated, has a tendency to excite admiration and astonishment, and to *impress us with a sense of our continual dependence on a Superior Power*. What an immense multiplicity of machinery must be in action, to enable us to breathe, to feel, and to walk! Hundreds of bones of diversified forms, connected together by various modes of articulation; hundreds of muscles to produce motion, each of them acting in at least ten different capacities, (see p. 490); hundreds of tendons and ligaments to connect the bones and muscles; hundreds of arteries to convey the blood to the remotest part of the system; hundreds of veins to bring it back to its reservoir the heart; thousands of glands secreting humours of various kinds from the blood; thousands of lacteal and lymphatic tubes, absorbing and conveying nutriment to the circulating fluid; millions of pores, through which the perspiration is continually issuing; an infinity of ramifications of nerves, diffusing sensation

[1] Contemplation of Nature, vol. i, p. 64.

throughout all the parts of this exquisite machine; and the heart at every pulsation exerting a force of a hundred thousand pounds, in order to preserve all this complicated machinery in constant operation! The whole of this vast system of mechanism must be in action before we can walk across our apartments! We admire the operation of a steam-engine, and the force it exerts. But, though it is constructed of the hardest materials the mines can supply, in a few months some of its essential parts are worn and deranged, even although its action should be frequently discontinued. But the animal machine, though constructed, for the most part, of the softest and most flabby substances, can go on without intermission in all its diversified movements, by night and by day, for the space of eighty or a hundred years! the heart giving ninety-six thousand strokes every twenty-four hours, and the whole mass of blood rushing through a thousand pipes of all sizes every six minutes! And is it *man* that governs these nice and complicated movements? Did *he* set the heart in motion, or endue it with the muscular force it exerts? And when it has ceased to beat, can *he* command it again to resume its functions? Man knows neither the secret springs of the machinery within him, nor the half of the purposes for which they serve, or of the movements they perform. Can any thing more strikingly demonstrate our dependence every moment on a Superior Agent, and that it is "in God we live and move and have our being"? Were a single pin of the machinery within us, and over which we have no control, either broken or deranged, a thousand movements might instantly be interrupted, and our bodies left to crumble into the dust.

It was considerations of this kind that led the celebrated physician Galen, who was a sceptic in his youth, publicly to acknowledge that a Supreme Intelligence must have operated in ordaining the laws by which living beings are constructed. And he wrote his excellent treatise, 'On the uses of the parts of the human frame,' as a solemn hymn to the Creator of the world. "I first endeavour from His work," he says, "to know myself, and afterwards by the same means to show him to others; to inform them how great is his wisdom, his goodness, his power." The late Dr. Hunter has observed, that Astronomy and Anatomy are the studies which present us with the most striking view of the two most wonderful attributes of the Supreme Being. The first of these fills the mind with the idea of his immensity, in the large-

ness, distances, and number of the heavenly bodies; the last astonishes us with his intelligence and art, in the variety and delicacy of animal mechanism.

(2.) The study of the animal economy has a powerful tendency *to excite emotions of gratitude.* Man is naturally a thoughtless and *ungrateful* creature. These dispositions are partly owing to *ignorance* of the wonders of the human frame, and of the admirable economy of the visible world; and this ignorance is owing to the want of those specific instructions which ought to be communicated by parents and teachers, in connection with religion. For there is no rational being, who is acquainted with the structure of his animal system, and reflects upon it with the least degree of attention, but must feel a sentiment of admiration and gratitude. The science which unfolds to us the economy of our bodies, shows us, on what an infinity of springs and motions and adaptations our life and comfort depend. And when we consider, that all these movements are performed without the least care or laborious effort on our part, if we be not altogether brutish, and insensible of our dependence on a Superior Power, we must be filled with emotions of gratitude towards Him "whose hands have made and fashioned us, and who giveth us life and breath and all things." Some of the motions to which I have adverted depend upon our will; and with what celerity do they obey its commands! Before we can rise from our chair, and walk across our apartment, a hundred muscles must be set in motion; every one of these must be relaxed or constricted, just to a certain degree, and no more; and all must act harmoniously at the same instant of time; and at the command of the soul, all these movements are instantaneously performed. When I wish to lift my hand to my head, every part of the body requisite to produce the effect is put in motion: the nerves are braced, the muscles are stretched or relaxed, the bones play in their sockets, and the whole animal machine concurs in the action, as if every nerve and muscle had heard a sovereign and resistless call. When I wish, the next moment, to extend my hand to my foot, all these muscles are thrown into a different state, and a new set are brought along with them into action; and thus we may vary, every moment, the movement of the muscular system, and the mechanical action it produces, by a simple change in our volition. Were we not daily accustomed to such varied and voluntary

movements, or could we contemplate them in any other machine, we should be lost in wonder and astonishment.

Besides these voluntary motions, there are a thousand important functions which have no dependence upon our will. Whether we think of it or not, whether we be sleeping or waking—sitting or walking—the heart is incessantly exerting its muscular power at the centre of the system, and sending off streams of blood through hundreds of pipes; the lungs are continually expanding and contracting their thousands of vesicles, and imbibing the vital principle of the air; the stomach is grinding the food; the lacteals and lymphatics are extracting nourishment for the blood; the liver and kidneys drawing off their secretions; and the perspiration issuing from millions of pores. These, and many other important functions with which we are unacquainted, and over which we have no control, ought to be regarded as the immediate agency of the Deity within us, and should excite our incessant admiration and praise.

There is one peculiarity in the constitution of our animal system which we are apt to overlook, and for which we are never sufficiently grateful; and that is, *the power it possesses of self-restoration.* A wound heals up of itself; a broken bone is made firm again by a callus; and a dead part is separated and thrown off. If all the wounds we have ever received were still open and bleeding afresh, to what a miserable condition should we be reduced? But by a system of internal powers, beyond all human comprehension as to the mode of their operation, such dismal effects are effectually prevented. In short, when we consider, that health depends upon such a numerous assemblage of moving organs, and that a single spring out of action might derange the whole machine, and put a stop to all its complicated movements, can we refrain from joining with the Psalmist in his pious exclamation, and grateful resolution, "How precious are thy wonderful contrivances concerning me, O God! how great is the sum of them! I will praise thee; for I am fearfully and wonderfully made. Marvellous are thy works, and that my soul knoweth right well."

History.

History embraces a record and description of past facts and events in reference to all the nations and ages of the world, in so far as they are known, and have been transmitted to our time. As Natural History contains a record of the operations of the Creator in the material world, so Sacred and Civil History embraces a record of his transactions in the moral and intellectual world, or, in other words, a detail of the plans and operations of his providence, in relation to the inhabitants of our globe.

Sacred and Civil History.

During the period of 3500 years from the creation of man, the sacred history contained in the Old Testament is our only source of information in reference to the state of mankind, and the events which happened to the human race throughout that long interval. From the creation of Adam to the Deluge—a period of about 2000 years, according to the Septuagint chronology—we have no authenticated account of what happened to the inhabitants of the world, but that which is recorded in the first eight chapters of the book of Genesis. And during a period of 1500 years after the flood, the Sacred history is still our only sure guide as to the events which took place among the nations of the earth. This history, however, relates chiefly to the inhabitants of Judea and the surrounding nations,—so that the greater portion of the history of man, in reference to all the other nations of the world, remains to be learned in a future state. The Old Testament records carry down our views of the history of man to the period of the Jewish captivity, and to about a hundred years posterior to that event, that is, to within four or five hundred years of the Christian era. About this period *Civil History* becomes definite and authentic, and fills up, in some measure, the chasm which is left in the Sacred History, so that, from this period downwards to the present time—with the exception of the New Testament records—we are indebted to civil or profane history, written by men of different nations, for all our knowledge of the transactions of mankind, and of the events which have befallen them during the bypast period of 2500 years.

Civil history has been divided into *Ancient* and *Modern* History. Ancient history stretches back as far as the authentic records of

nations can carry us; but we have no records to be depended upon, separate from Revelation, which can carry us farther back in the lapse of past ages than about a thousand years before the Christian era. This department of historic record comprehends the history of the *Egyptians*—the *Assyrians* and *Babylonians*—the *Jews* and *Phœnicians*—the *Medes* and *Persians*—the *Scythians* and *Celts*—the *Carthaginians*—and particularly the history of the *Greeks* and of the *Romans*, which forms by far the larger portion of ancient history, extending from the building of Rome in the year 753 before Christ, to the subversion of the Roman empire in the 6th century of the Christian era, a period of about 1300 years—*Modern* history commences where ancient history ends, about the 6th or 7th century, and comprises the history of France, Germany, Britain, Spain, Portugal, Italy, and other countries in Europe, together with what is known in modern times respecting the events which have happened in the kingdoms of Asia and Africa, and in the settlements of Australasia and America. In reference to all such historical records, it is deeply to be lamented that they contain little else than details of wars, slaughters, and devastations, and chiefly present to our view pictures of extortion, assassinations, wholesale robberies, the destruction of empires, the burning of cities, and the desolation of provinces. From these records, however, we may learn such instructions as the following:

Through the medium of sacred history we learn the period and the manner of man's creation;—the reason of his fall from the primitive state of integrity in which he was created, and the dismal consequences which ensued;—the various movements of providence in order to his recovery, and the means by which human redemption was achieved;—the manner in which the Gospel was at first promulgated, the countries into which it was carried, and the important effects it produced. Through the medium of civil history we learn the deep and universal depravity of mankind, as exhibited in the wars, dissensions, and ravages which have desolated our fallen race in every period and in every land; we learn the desperate wickedness of the human heart in the more private acts of ferocity, cruelty, and injustice, which in all ages men have perpetrated upon each other;—we behold the righteousness of the supreme Ruler of the world, and the equity of his administration in the judgments which have been inflicted on wicked nations; and the improbability, nay, the *impossibility*,

of men being ever restored to moral order and happiness, without a more extensive diffusion of the blessings of the Gospel of peace, and a more cordial acquiescence in the requirements of the divine law.

Such being some of the benefits to be derived from history, it requires no additional arguments to show that this branch of knowledge should occasionally form a subject of study to every intelligent Christian. But in order to render the study of history subservient to the interests of religion, it is not enough merely to gratify our curiosity and imagination, by following out a succession of memorable events, by tracing the progress of armies and of battles, and listening to the groans of the vanquished and the shouts of conquerors. This would be to study history merely as sceptics, as atheists, or as writers of novels. When we contemplate the facts which the historian presents to our view, we ought to raise our eyes to Him who is the Governor among the nations, "who doth according to his will in the armies of heaven and among the inhabitants of the earth," and who overrules the jarring interests of mortals, for promoting the prosperity of that kingdom which shall never be moved. We should view the immoral propensities and dispositions of mankind, as portrayed in the page of history, as evidences of the depravity of our species, and as excitements to propagate, with unremitting energy, the knowledge of that Religion whose sublime doctrines and pure precepts alone can counteract the stream of human corruption, and unite all nations in one harmonious society. We should view the contests of nations, and the results with which they are accompanied, as guided by that invisible hand which "mustereth the armies to the battle;" and should contemplate them either as the accomplishment of divine predictions, as the inflictions of retributive justice, as paving the way for the introduction of rational liberty and social happiness among men, or as ushering in that glorious period when "the knowledge of the Lord shall cover the earth," and the nations shall learn war no more.

Prophetic History.

The histories to which we have above alluded have reference to the transactions of *past* ages, and to events which have already taken place in the course of the Divine administration. We may also notice a series of events which may be arranged under the

denomination of *prophetical history.* Under the Old Testament dispensation, inspired prophets were raised up to announce facts and events which were to be realized in the future ages of time, in reference both to the nation of the Jews and to the world at large. They foretold the coming of Messiah, and some of the leading events which were to happen during the progress of his reign—that a virgin was to conceive and bear a son—that Bethlehem-Ephratah was to give him birth—that his name was to be called the "Mighty God, the Father of eternity, and the Prince of peace,"—that he should be "numbered with the transgressors and bear the sins of many,"—"cut off from the land of the living," "swallow up death in victory," arise triumphant from the grave, and ascend to heaven having received gifts for men, and vanquished every foe. The prophet Daniel predicted the very time when the Messiah should make his appearance, and the circumstances which should precede and accompany it. He also predicted several events which were to happen in reference to the Medes and Persians, the Macedonian empire, the times of Alexander the Great, Ptolemy Philadelphus, Antiochus Epiphanes, Philip of Macedon, and the persecutions in the days of the Macabees, several hundreds of years before some of the events happened.—These and similar events foretold by inspiration may be considered as part of the *prophetical history* made known to the church and nation of Israel.

In relation to us there is also a portion of prophetical history revealed. This is contained in the writings of several of the ancient prophets, especially in the prophecies of Isaiah, Jeremiah, and Daniel, and more particularly in the book of Revelation. In this book, John, when in the isle of Patmos, was commanded to "write the things that should be hereafter." In the visions here recorded there appears to have been presented to the view of the Apostle, an outline of the whole of the series of Divine dispensations which should happen in regard to the Church and the world, from the period in which he lived, throughout all the succeeding periods of time, till the general consummation of all things in reference to our world. These predictions chiefly refer to the constitution and fates of the Christian Church, and the changes through which it should pass, during its several periods of propagation, corruption, and reformation, from its beginning till its consummation in the heavenly state—and were intended as a

standing monument to the members of the Church, that they might learn what destinies were to attend it, and what persecutions it was to endure, that they might be enabled to bear up under suffering, and to perceive that all its changes and afflictions would ultimately arrive at a glorious termination. Many of the events predicted we can now retrace as having been actually realized, such as the persecutions of the early Christians by the Roman Emperors—the corruptions which were gradually introduced into the Church—the prevalence of wars, slaughters, and devastations among the nations—the rise of Antichrist, and his influence in enslaving the minds of men and deceiving the nations, and some of the circumstances which are preparatory to his final downfall.

In prophetical history we cannot trace the *minute circumstances* which may accompany certain important events, as we can do in relation to the occurrences of past ages, when related by credible historians. We can perceive only some of the grand leading features of those future scenes which are portrayed in the writings of the prophets—which are sometimes exhibited in visionary and symbolical representations. But the general characteristics of the events predicted may in most instances be clearly perceived. The following are some of the events in prophetical history in which we are interested, and which may be distinctly traced in the predictions of the ancient prophets.—That the wars and devastations which have hitherto convulsed the kingdoms of the earth shall ultimately cease—that swords shall be "beaten into ploughshares, and spears into pruning hooks," and that the nations "shall delight themselves in an abundant peace"—that "the kingdoms of this world shall become the kingdoms of our Lord and of his Messiah"—that "the Gospel shall be preached to all the nations of the earth;" that the veil of ignorance shall be withdrawn from the benighted nations, and the light of Divine truth be progressively diffused, till "the earth be full of the knowledge of God as the waters cover the sea,"—that "all kings shall fall down before Messiah, and all nations serve him, and the whole earth be filled with his glory;" and that "righteousness and praise shall spring forth before all nations"—that "the earth shall yield its increase," and its desolate wastes be cultivated and inhabited, and that "every man shall sit under his own vine and fig tree," none daring to make him afraid; for at that period "there shall be nothing to hurt or destroy, saith the Lord,"--that the Jews shall be re-

called from their wanderings and dispersions among the nations, and be amalgamated with the Christian Church, and probably reinstated in the possession of the land of their fathers—that "the idols of the nations will be abolished, and cast to the moles and to the bats"—that the Christian Church shall ultimately be united in one harmonious society, and "the name of the Lord be ONE throughout all the earth"—that the happy era when these events shall be realized will continue during a lapse of ages, after Antichrist and the false prophet that deceived the nations shall have fallen to rise no more—that, after the enemies of the Church are destroyed, and the designs of the Divine administration with regard to this world are accomplished, the "great white throne shall be erected, the dead both small and great shall stand before Him who sits upon it;—all that are in their graves shall hear the voice of the Son of God and shall come forth," and "they shall be judged every man according to his works." The physical constitution of our globe will undergo an important change; the aërial "heavens shall pass away with a mighty noise; the elements shall melt with fervent heat, the earth also and the works that are therein shall be burned up;" and from the ashes of the conflagration new heavens and a new earth will be constructed and arranged wherein righteousness shall for ever dwell. The fates of all the thousands of millions of the race of Adam will then be determined, a new and higher series of events will commence, and the righteous shall be transported into the regions of bliss to be "for ever with the Lord," and shall "shine forth as the sun in the kingdom of their Father, and as the stars for ever and ever."

Such are some of the facts of prophetical history which are yet to be realized; and from the statement now made it appears that they are far more sublime, interesting, and important, than any events that have yet happened in the moral government of God during the generations that are past. And as we ought to learn instruction from the records of the past dispensations of the Almighty towards the Church and the world, so we ought to learn wisdom, as to our duty in reference to the predicted events that are yet to take place in the future ages of time. As man is an agent in the hand of God in accomplishing his providential purposes, so we ought to consider whether, by our conduct, we are attempting to frustrate the designs of the Almighty, or are "workers together with Him," in fulfilling his gracious purposes,

and promoting the illumination and regeneration of the world. If we are abettors of war, slavery, tyranny, oppression, and injustice, we are frustrating, so far as in our power, the plans of the Omnipotent, and retarding the approach of the millenial era. If we are engaged in every branch of holy activity, doing what in us lies to dispel the mists of ignorance, to diffuse useful knowledge among all ranks, to undermine and correct the evils which have crept into the social system—to establish institutions for the moral and intellectual instruction of the young—to promote "PEACE on earth and good will among men"—and to diffuse Divine truth around us in our native land, and among the benighted tribes of the heathen world—then are we co-operating with the Divine administration, and hastening forward the period when Peace shall reign triumphant over the nations, when the knowledge of the Lord shall be diffused over the world, and "the whole earth be filled with his glory."

Thus I have taken a very cursory survey of some of those Sciences which stand in a near relation to the objects of Religion; and which may indeed be considered as forming so many of its subordinate branches. There are many other departments of knowledge, which at first view do not seem to have any relation to Theological science; and yet, on a closer inspection, will be found to be essentially connected with the several subjects of which I have been treating. For example—some may be apt to imagine that Arithmetic, Geometry, Trigonometry, and other branches of Mathematics, can have no relation to the leading objects of Religion. But if these sciences had never been cultivated, the most important discoveries of astronomy, geography, natural philosophy, and chemistry, would never have been made; ships could not have been navigated across the ocean; distant continents, and the numerous "isles of the sea," would have remained unexplored, and their inhabitants left to grope in the darkness of heathenism; and most of those instruments and engines by which the condition of the human race will be gradually meliorated, and the influence of Christianity extended, would never have been invented. Such is the dependence of every branch of useful knowledge upon another, that were any one portion of science, which

has a practical tendency, to be discarded, it would prevent to a certain degree the improvement of every other. And consequently if any one science can be shown to have a connexion with religion, all the rest must necessarily stand in a certain relation to it. It must, therefore, have a pernicious effect on the minds of the mass of the Christian world, when preachers in their sermons endeavour to undervalue scientific knowledge, by attempting to contrast it with the doctrines of Revelation. It would be just as reasonable to attempt to contrast the several doctrines, duties, and facts recorded in the New Testament, with each other, in order to determine their relative importance, and to show which of them might be altogether overlooked and discarded. The series of facts and of divine revelations comprised in the Bible, the moral and political events which diversify the history of nations; and the physical operations that are going on among the rolling worlds on high, and in the chemical changes of the invisible atoms of matter—are all parts of *one* comprehensive system, under the direction of the Eternal Mind; every portion of which must have a certain relation to the whole. And therefore, instead of attempting to degrade one part of the Divine fabric, in order to enhance another, our duty is to take an expansive view of the whole, and to consider the symmetry and proportion of its parts, and their mutual bearings and relations, in so far as our opportunities and the limited faculties of our minds will permit.

If the remarks which have been thrown out in this chapter, respecting the connection of the Sciences with Religion, have any foundation, it will follow—that Sermons, Lectures, systems of Divinity, and Religious Periodical works, should embrace occasional illustrations of such subjects, for the purpose of expanding the conceptions of professed Christians, and of enabling them to take large and comprehensive views of the perfections and providence of the Almighty. It is much to be regretted, that so many members of the Christian church are absolute strangers to such studies and contemplations; while the time and attention that might have been devoted to such exercises, have in many cases been usurped by the most grovelling affections, by foolish pursuits, by gossiping chit-chat, and slanderous conversation. Shall the most trifling and absurd opinions of ancient and modern heretics be judged worthy of attention, and occupy a place in Religious journals, and even in discussions from the pulpit; and

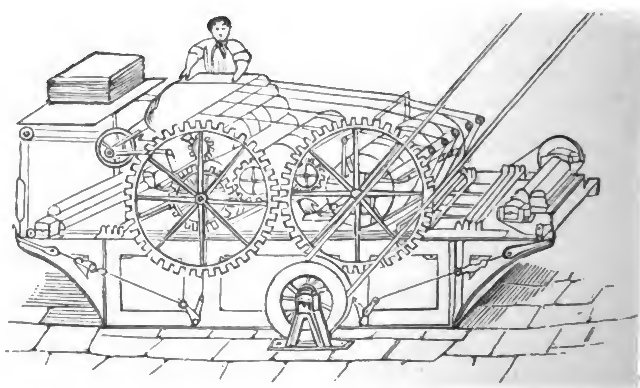
shall "the mighty acts of the Lord," and the visible wonders of his power and wisdom, be thrown completely into the shade! To survey with an eye of intelligence the wide-extended theatre of the Divine operations—to mark the agency of the Eternal Mind in every object we behold, and in every movement within us and around us, are some of the noblest attainments of the rational soul; and, in conjunction with every other Christian study and acquirement, are calculated to make "the man of God perfect, and thoroughly furnished unto every good work." By such studies we are in some measure assimilated to the angelic tribes, whose powers of intellect are for ever employed in such investigations; and are gradually prepared for bearing a part in their immortal hymn—"Great and marvellous are thy works, Lord God Almighty; just and true are thy ways, thou King of Saints! Thou art worthy to receive glory and honour and power; for thou hast created all things and for thy pleasure they are and were created."

CHAPTER III.

THE RELATION WHICH THE INVENTIONS OF HUMAN ART BEAR TO THE OBJECTS OF RELIGION.

In this chapter I shall briefly notice a few philosophical and mechanical inventions, which have an obvious bearing on Religion, and on the general propagation of Christianity among the nations.

The first, and perhaps the most important of the inventions to which I allude is the Art of Printing. This art appears to have



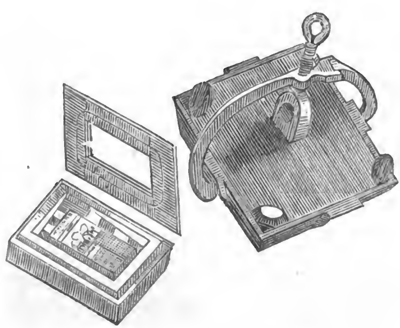
STEAM-PRESS PRINTING.

been invented (at least in Europe) about the year 1430, by one Laurentius, or Laurence Koster, a native of Haerlem, a town in Holland. As he was walking in a wood near the city, he began to cut some letters upon the rind of a beech tree, which, for the sake of gratifying his fancy, being impressed on paper, he printed

one or two lines as a specimen for his grandchildren to follow. This having succeeded, he meditated greater things; and first of all invented a more glutinous writing-ink, because he found the common ink sunk and spread; and thus formed whole pages of wood with letters cut upon them.[1] By the gradual improvement

[1] I am aware that the honour of this invention has been claimed by other cities besides Haerlem, particularly by Strasburg, and Mentz, a city of Germany; and by other individuals besides Laurentius, chiefly by one *Faust*, commonly called Dr. Faustus; by Schoeffer, and by Gutemberg. It appears that the art, with many of its implements, was stolen from Laurentius by one of his servants, whom he had bound by an oath to secrecy, who fled to Mentz, and first commenced the process of printing in that city. Here the art was improved by Faust and Schoeffer, by their invention of *metallic* instead of *wooden* types, which were first used. When Faust was in Paris, disposing of some Bibles he had printed, at the low price (as was then thought) of sixty crowns, the number and uniformity of the copies he possessed created universal agitation and astonishment. Informations were given to the police against him as a magician, his lodgings were searched, and a great number of copies being found, they were seized; the red ink with which they were embellished was said to be his blood; it was seriously adjudged that he was in league with the Devil: and if he had not fled from the city, most probably he would have shared the fate of those whom ignorant and superstitious judges, at that time, condemned for witchcraft. From this circumstance let us learn to beware how we view the inventions of genius, and how we treat those whose ingenious contrivances may afterwards be the means of enlightening and meliorating mankind.—See Appendix.

Various improvements have been made of late years in the art of Printing. The art of *Stereotyping*, which was invented by Mr. Ged of Edinburgh, in 1725, but was not brought into general use till after the beginning of



STEREOTYPING APPARATUS

of the art of printing, and its application to the diffusion of knowledge, a new era was formed in the annals of the human race, and in the progress of science, religion, and morals. To it we are chiefly indebted for our deliverance from ignorance and error, and for most of those scientific discoveries and improvements in the arts which distinguish the period in which we live. Without its aid, the Reformation from Popery could scarcely have been

the present century, is now extensively used, both in Great Britain and America, in the printing of Bibles and such books as have an extensive circulation. When a page is intended to be *stereotyped*, the types are, in the first instance, put up in the usual way; but instead of being carried to the press, the page is plastered over with liquid stucco to the thickness of about half an inch, so that a level cake is formed on the surface of the types. As soon as the stucco hardens, the cake is separated from the types, and on being turned up, shows a complete mould-like representation of the faces of the types; and there being no longer any use for the types they are carried off and distributed. After the cake is hardened by putting it into an oven, it is next laid in a square iron pan, at the bottom of which is a moveable plate upon which the mould is placed with its face downwards. The pan is then immersed in a pot of molten lead, and when the lead has run into the mould side of the cake, and formed a thin plate all over, there is produced the perfect appearance of the faces of the types on which the stucco was plastered. The stereotype plates, thus prepared, are made ready for the press, by placing them on metal or wooden blocks, so that both plate and block make up the exact height of a page of real types.—In this manner, any number of copies of a book may be printed at any time, without again incurring the trouble and expence of resetting the types, as is necessary to be done in printing new editions. A mode of casting from a paper mould, instead of stucco, has been lately introduced; and is, in some respects, an improvement.

Steam-printing—which is now in very general use—appears to have been first introduced by Mr. König, a German, about 1804. The *Times* newspaper of November 28, 1814, appears to have been the first ever printed by machinery propelled by steam, and the numbers of that paper have been thrown off by the same process ever since. A machine of this description, with one cylinder, throws off from 900 to 1200 sheets in an hour on one side, requiring two boys, one to lay on the paper and another to receive it when printed. A machine with two cylinders throws off at the rate of from 1600 to 2200 an hour, requiring two boys to lay on the sheets and two to take them off—exclusively for newspapers. By the erection of such steam-presses, the three grand requisites, speediness of execution, quantity, and cheapness of labour, are secured to an extent which could scarcely have been anticipated in a preceding age, and which is calculated to supply the exigencies of the times in which we live, when knowledge of every description is rapidly diffusing itself among all ranks of the community. A machine, the invention of Mr. Applegarth, is now used by the *Times*, by which 10,000 impressions an hour are regularly obtained.

THE INVENTION OF PRINTING.

achieved; for had the books of Luther, one of the first reformers, been multiplied by the slow process of handwriting and copying, they could never have been diffused to any extent; and the influence of bribery and of power might have been sufficient to have arrested their progress, or even to have erased their existence. But, being poured forth from the press in thousands at a time, they spread over the nations of Europe like an inundation, and with a rapidity which neither the authority of princes, nor the schemes of priests and cardinals, nor the bulls of popes, could counteract or suspend. To this noble invention it is owing that copies of the Bible have been multiplied to the extent of many millions—that ten thousands of them are to be found in every Protestant country—and that the poorest individual who expresses a desire for it, may be furnished with the "Word of Life," which will guide him to a blessed immortality. That Divine light which is destined to illuminate every region of the globe, and to sanctify and reform men of all nations and kindreds and tongues, is accelerated in its movements, and directed in its course through the nations, by the invention of the Art of Printing; and ere long it will distribute among the inhabitants of every land the "Law and the Testimony of the Most High," to guide their steps to the regions of eternal bliss. In short, there is not a more powerful engine in the hand of Providence, for diffusing the knowledge of the nature and the will of the Deity, and for accomplishing the grand objects of Revelation, than the art of multiplying books, and of conveying intelligence through the medium of the press. Were no such art in existence, we cannot conceive how an extensive and universal propagation of the doctrines of Revelation could be effected, unless after the lapse of an indefinite number of ages. But with the assistance of this invention, in its present improved state, the island of Great Britain alone, within less than a hundred years, could furnish a copy of the Scriptures to every inhabitant of the world, and could defray the expence of such an undertaking with much more ease and with a smaller sum than were necessary to finish the political warfare in which we were lately engaged.

These considerations teach us that the ingenious inventions of the human mind are under the direction and control of the Governor of the world—are intimately connected with the accomplishment of the plans of his Providence; and have a tendency, either directly or indirectly, to promote, over every region of the earth,

the progress and extension of the kingdom of the Redeemer. They also show us from what small beginnings the most magnificent operations of the Divine economy may derive their origin. Who could have imagined that the simple circumstance of a person amusing himself, by cutting a few letters on the bark of a tree, and impressing them on paper, was intimately connected with the mental illumination of mankind? and that the art which sprung from this casual process was destined to be the principal mean of illuminating the nations, and of conveying to the ends of the earth the "salvation of our God?" But "He who rules in the armies of heaven and among the inhabitants of the earth," and who sees "the end from the beginning," overrules the most minute movements of all his creatures, in subserviency to his ultimate designs, and shows himself in this respect to be "wonderful in counsel and excellent in working."[1]

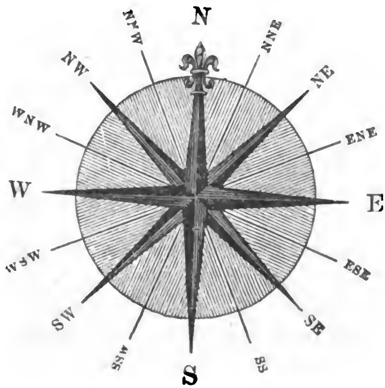
[1] Anastatic Printing.—A new process of printing, under this title, was made public a few years ago. At that period certain obstacles were in the way of its practical application to a certain extent, which have since been completely overcome. The first number of an octavo periodical, now in course of publication, being out of print, its conductors resolved to make a trial of this method, and the result has been perfectly satisfactory. A copy was handed to the inventor, Messrs. Siemans, who, without setting up any type, produced a perfect fac-simile of both letter-press and wood engravings.—The Anastatic process is as follows:—Impressions are taken on copper from the ink on the original, and, by the use of chemical agency, fixed thereon; and copies can be taken to any extent in a manner somewhat analogous to lithography, but much faster. M. Baldamus of Berlin was the first who succeeded in transferring drawings, but only such as had been recently printed. His invention having lain dormant for several years, was then entrusted to the care of Messrs. E. W. and C. W. Siemans, who immediately endeavoured to apply it to renewing impressions of old and scarce works, or those out of print. They succeeded in renewing the indurated ink without dissolving or destroying it. By the steam-press made by Ransom and Simms of Ipswich, 1000 copies per hour have been taken. A patent for this invention has been taken out for England, but it is of comparatively little use except as a curiosity of art. Though great things were expected of it, but slight practical advantages have resulted. The process is useful, however, in enabling us to copy in a rough way old prints, music, etc.

The Mariner's Compass.

Another invention which has an intimate relation to religion is, the *Art of Navigation and the invention of the* Mariner's Compass.

Navigation is the art of conducting a ship through the sea from one port to another. This art was partly known and practised in

Fig. 37.



CARD OF THE MARINER'S COMPASS.

the early ages of antiquity by the Phœnicians, the Carthaginians, the Egyptians, the Romans, and other nations of Europe and Asia. But they had no guide to direct them in their voyages, except the sun in the day-time, and the stars by night. When the sky was overcast with clouds they were thrown into alarms, and durst not venture to any great distance from the coast, lest they should be carried forward in a course opposite to that which they intended, or be driven against hidden rocks or unknown shores. The danger and difficulty of the navigation of the ancients on this account may be learned from the deliberations, the great preparations, and the alarms of Homer's heroes, when they were about to cross the Ægean sea, an extent of not more than 150 miles; and the expedition of the Argonauts, under Jason, across the sea of Marmora and the Euxine to the island of Colchis, a distance of only four or five hundred miles, was viewed as a most wonderful exploit, at which even the gods themselves were said to be amazed. The same thing appears from the narration we have in the Acts of the Apostles of Paul's voyage from Cesarea to Rome. "When," says

Luke, "neither sun nor stars in many days appeared, and no small tempest lay on us, all hope that we should be saved was then taken away." Being deprived of these guides, they were tossed about in the Mediterranean, not knowing whether they were carried to north, south, east or west. So that the voyages of antiquity consisted chiefly in creeping along the coast, and seldom venturing beyond sight of land: they could not, therefore, extend their excursions by sea to distant continents and nations; and hence the greater portion of the terraqueous globe and its inhabitants were to them altogether unknown. It was not before the invention of the mariner's compass that distant voyages could be undertaken, that extensive oceans could be traversed, and an intercourse carried on between remote continents and the islands of the ocean.

It is somewhat uncertain at what precise period this noble discovery was made; but it appears pretty evident that the mariner's compass was not commonly used in navigation before the year 1420, or only a few years before the invention of printing.[1] The loadstone, in all ages, was known to have the property of attracting iron; but its tendency to point towards the north and south seems to have been unnoticed till the beginning of the twelfth century. About that time some curious persons seem to have amused themselves by making to swim, in a basin of water, a loadstone suspended on a piece of cork; and to have remarked, that, when left at liberty, one of its extremities pointed to the north. They had also remarked, that, when a piece of iron is rubbed against the loadstone, it acquires also the property of turning towards the north, and of attracting needles and filings of iron. From one experiment to another, they proceeded to lay a needle, touched with the magnet, on two small bits o straw floating on the water, and to observe that the needle invariably turned its

[1] The invention of the compass is usually ascribed to Flavio Gioia of Amalfi, in Campania, about the year 1302; and the Italians are strenuous in support of this claim. Others affirm that Marcus Paulus, a Venetian, having made a journey to China, brought back the invention with him in 1260. The French also lay claim to the honour of this invention, from the circumstance that all nations distinguish the north point of the card by a *fleur de lis;* and, with equal reason, the English have laid claim to the same honour, from the name *compass*, by which most nations have agreed to distinguish it. But whoever were the inventors, or at whatever period this instrument was first constructed, it does not appear that it was brought into general use before the period mentioned in the text.

COLUMBUS DISCOVERING AMERICA.

point towards the north. The first use they seem to have made of these experiments was to impose upon simple people by the appearance of *magic*. For example, a hollow swan, or the figure of a mermaid, was made to swim in a basin of water, and to follow a knife with a bit of bread upon its point, which had been previously rubbed on the loadstone. The experimenter convinced them of his power, by commanding, in this way, a needle laid on the surface of the water, so turn its point from the north to the east, or in any other direction. But some geniuses, of more sublime and reflective powers of mind, seizing upon these hints, at last applied these experiments to the wants of navigation, and constructed an instrument, by the help of which the mariner can now direct his course to distant lands through the vast and pathless ocean. Fig. 37 gives a general representation of the card of the mariner's compass.

In consequence of the discovery of this instrument, the coasts of almost every land on the surface of the globe have been explored, and a regular intercourse opened up between the remotest regions of the earth. Without the help of this noble invention, America, in all probability, would never have been discovered by the eastern nations, the vast continent of Australia, the numerous and interesting islands in the Indian and Pacific oceans, the Isles of Japan, and other immense territories inhabited by human beings, would have remained as much unknown and unexplored as if they had never existed. And as the nations of Europe and the western parts of Asia were the sole depositories of the records of Revelation, they could never have conveyed the blessings of salvation to remote countries, and to unknown tribes of mankind, of whose existence they were entirely ignorant. Even although the whole terraqueous globe had been sketched out before them, in all its aspects and bearings, and ramifications of islands, continents, seas, and oceans, and the moral and political state of every tribe of its inhabitants displayed to view, without a guide to direct their course through the billows of the ocean, they could have afforded no light, and no relief to cheer the distant nations "who sit in darkness and in the shadow of death." Though the art of printing had been invented; though millions of Bibles were now prepared, adequate to the supply of all the "kindreds of the heathen;" though ships in abundance were equipped for the enterprise, and thousands of missionaries ready to embark, and to devote their

lives to the instruction of the Pagan world; all would be of no avail, and the "salvation of God" could never be proclaimed to the ends of the world, unless they had the mariner's compass to guide their course through the trackless ocean.

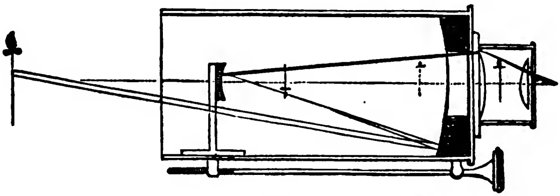
In this invention, then, we behold a proof of the agency of Divine Providence in directing the efforts of human genius to subserve the most important designs, and contemplate a striking specimen of the "manifold wisdom of God." When the pious and contemplative Israelite reflected on the declaration of the prophets, that "the glory of Jehovah should be revealed, and that all flesh should see it together,"—from the state of the arts which then existed, he must have felt many difficulties in forming a conception of the *manner* in which such predictions should be realized. "The great and wide sea," now termed the Mediterranean, formed the boundary of his view, beyond which he was unable to penetrate. Of the continents and "the isles afar off," and of the far more spacious oceans that lay between, he had no knowledge; and how "the ends of the earth" were to be reached he could form no conception; and in the midst of his perplexing thoughts, he could find satisfaction only in the firm belief that "with God all things are possible." But now we are enabled not only to contemplate the grand designs of the Divine economy, but the principal means by which they shall all, in due time, be accomplished, in consequence of the progress of science and art, and of their consecration to the rearing and extension of the Christian Church.

The two inventions to which I have now adverted may, perhaps, be considered as among the most striking instances of the connexion of human art with the objects of Religion. But there are many other inventions which, at first view, do not appear to bear so near a relation to the progress of Christianity, and yet have an ultimate reference to some of its grand and interesting objects.

The Telescope

We might be apt to think, on a slight view of the matter, that there can be no immediate relation between the grinding and polishing of an optic glass, and fitting two or more of them in a tube—and the enlargement of our views of the operations of the Eternal Mind. Yet the connexion between these two objects, and the dependence of the latter upon the former, can be fairly demon-

strated.—The son of a spectacle-maker of Middleburg in Holland, happening to amuse himself in his father's shop, by holding two glasses between his finger and thumb, and varying their distances, perceived the weathercock of the church spire opposite to him much



THE GREGORIAN REFLECTING TELESCOPE.

larger than ordinary, and apparently much nearer, and turned upside down. This new wonder excited the amazement of the father; he adjusted two glasses on a board, rendering them moveable at pleasure; and thus formed the first rude imitation of a perspective glass, by which distant objects are brought near to view. Galileo, a philosopher of Tuscany, hearing of the invention, set his mind to work, in order to bring it to perfection. He fixed his glasses at the end of long organ-pipes, and constructed a telescope, which he soon directed to different parts of the surrounding heavens. He discovered four moons revolving round the planet Jupiter—spots on the surface of the Sun, and the rotation of that globe around its axis—mountains and valleys in the Moon—and numbers of fixed stars where scarcely one was visible to the naked eye. These discoveries were made about the year 1610, a short time after the first invention of the telescope. Since that period, this instrument has passed through various degrees of improvement, and by means of it, celestial wonders have been explored in the distant spaces of the universe, which, in former times, were altogether concealed from mortal view. By the help of telescopes, combined with the art of measuring the distances and magnitudes of the heavenly bodies, our views of the Grandeur of the Almighty, of the plentitude of his Power, and of the *extent* of his universal Empire, are extended far beyond what could have been conceived in former ages. Our prospects of the range of the divine opera-

tions are no longer confined within the limits of the world we inhabit; we can now plainly perceive, that the kingdom of God is not only "an everlasting dominion," but that it extends through the unlimited regions of space, comprehending within its vast circumference thousands of suns, and ten thousands of worlds, all arranged in majestic order, at immense distances from one another, and all supported and governed "by Him who rides on the heaven of heavens," whose greatness is unsearchable, and whose understanding is infinite.

The telescope has also demonstrated to us the *literal truth* of those scriptural declarations which assert that the stars are "innumerable." Before the invention of this instrument, not more than about a thousand stars could be perceived by the unassisted eye in the clearest night. But this invention has unfolded to view not only thousands, but hundreds of thousands, and millions of those bright luminaries, which lie dispersed in every direction throughout the boundless dimensions of space. In the *Milky Way* —a whitish zone or circle which surrounds the heavens—more than ten millions of stars might be distinguished by means of the best telescopes. And the higher the magnifying and illuminating powers of the telescope are, the more numerous these celestial orbs appear; leaving us no room to doubt, that countless myriads more lie hid in the distant regions of creation, far beyond the reach of the finest glasses that can be constructed by human skill, and which are known only to Him "Who counts the number of the stars, and calls them by their names."

In short, the telescope may be considered as serving the purpose of a vehicle for conveying us to the distant regions of space. We would consider it as a wonderful achievement, could we transport ourselves two hundred thousand miles from the earth, in the direction of the Moon, in order to take a nearer view of that celestial orb. But this instrument enables us to take a much nearer inspection of that planet than if we had actually surmounted the force of gravitation, traversed the voids of space, and left the earth 230,000 miles behind us. For, supposing such a journey to be accomplished, we should still be ten thousand miles distant from that orb. But a telescope which magnifies objects 240 times, can carry our views within ONE thousand miles of the Moon; and a telescope, such as Sir W. Herschel's 40 feet reflector, which magnifies 6000 times, would enable us to view the mountains and valleys

of the moon as if we were transported to a point about 40 miles from her surface.[1] We can view the magnificent system of the planet Saturn, by means of this instrument, as distinctly, as if we had performed a journey eight hundred millions of miles in the direction of that globe; which, at the rate of 50 miles an hour, would require a period of more than eighteen hundred years to accomplish. By the telescope we can contemplate the region of the fixed stars, their arrangement into systems, and their immense numbers, with the same distinctness and amplitude of view, as if we had actually taken a flight of ten hundred thousand millions of miles into those unexplorable regions, which could only be accomplished in several millions of years, though our motion were as rapid as a ball projected from a loaded cannon. We should justly consider it as a noble endowment for enabling us to take an extensive survey of the works of God, if we had the faculty of transporting ourselves to such immense distances from the sphere we now occupy; but by means of the telescopic tube, we may take nearly the same ample views of the dominions of the Creator, without stirring a foot from the limits of our terrestrial abode. This instrument may, therefore, be considered as a providential gift bestowed upon mankind, to serve, in the mean time, as a *temporary substitute*, for those powers of rapid flight with which the seraphim are endowed, and for those superior faculties of motion with which man himself may be invested, when he arrives at the summit of moral perfection.[2]

A telescope has been constructed by the Earl of Rosse, far surpassing any instrument of the kind that had previously been attempted, and which promises to be the mean of enriching astronomy with valuable discoveries, and of enabling us to penetrate much farther into the regions of infinite space than what former astronomers supposed to be possible. This instrument is a *reflecting* telescope. The great speculum is six feet diameter, five and a half inches thick at the edges, and five inches at the centre, and its weight is about three *tons*. Its composition is copper and tin—126 parts of copper to fifty-seven and a half of tin. The price of the copper alone was reckoned at about £100. By grinding and polishing, its thickness was reduced about one-eighth of an inch. Its focal distance is about fifty-four feet. The casting of this speculum took place in April, 1842, which, with all the mul-

[1] See Appendix [2] See Appendix

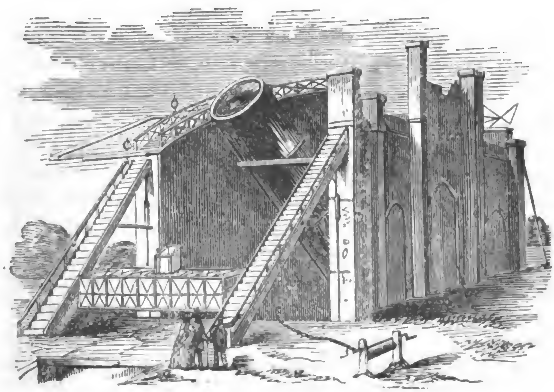
tifarious operations connected with it, was accomplished without any accident, and with a degree of success beyond expectation. The speculum has a reflecting surface of 4071 square inches, while that of Sir W. Herschel's forty feet telescope had only 1811 square inches on its polished surface; so that the quantity of light reflected from this speculum is considerably more than double that of Herschel's largest reflector; and it is chiefly on the quantity of light either transmitted or reflected, that the power of telescopes to penetrate into space depends. The process of grinding this speculum was conducted under water, and the moving power employed was a steam engine of three horse power. The substance made use of to wear down the surface was emery and water, a constant supply of these was kept between the grinder and the speculum. It required six weeks to grind it to a fair surface.

The tube of this telescope is fifty-six feet long, including the speculum box, and is made of deal, one inch thick, hooped with iron. On the inside, at intervals of eight feet, there are rings of iron, three inches in depth, and one inch broad, for the purpose of strengthening the sides. The diameter of the tube is seven feet. It is fixed to masonry in the ground, to a large universal hinge, which allows it to turn in all directions. At twelve feet distance on each side, a wall is built, seventy-two feet long, forty-eight high on the outer side, and fifty-six on the inner, the walls being twenty-four feet distant from each other, and lying exactly in the meridional line. When directed to the south, the tube may be lowered till it become almost horizontal; but when pointed to the north, it only falls till it is parallel to the earth's axis, pointing then to the pole of the heavens. Its lateral movements take place only from wall to wall, and this commands a view for half an hour on each side of the meridian—that is, the whole of its motion from east to west is limited to fifteen degrees. The tube and speculum, including the bed on which the speculum rests, weigh about fifteen tons.

FIGURE 38 is a representation of Lord Rosse's telescope, with part of the buildings with which it is connected. The telescope rests on an universal joint, placed on masonry about six feet below the ground, and it is elevated and depressed by a chain and windlass, and though it weighs fifteen tons, the instrument is raised by two men with great facility. Of course it is counterpoised in every direction. The observer when at work, stands in one of

four galleries, the three highest of which are drawn out from the western wall, while the fourth, or lowest, has for its base an elevating platform, along the horizontal surface of which a gallery slides from wall to wall, by machinery within the observer's reach, but which a child may work. When the telescope is directed to an object near the zenith, the observer stands at an elevation at least fifty feet above the ground. The figure represents only the upper part of the tube of the telescope, at which the observer

FIG. 38.



LORD ROSSE'S TELESCOPE.

stands when making his observations; and as the telescope is at present of the Newtonian construction, he looks in at the upper part of the *side* of the great tube; but it is intended to throw aside the plain speculum, and to adopt the *front view*, when the observer will look directly down the tube on the image formed by the great speculum.

Several important discoveries have already been made by this telescope, particularly in relation to the *Nebulæ*. Several nebulæ which were formerly supposed to be only immense masses of luminous substances, have been resolved into starry systems. The circular nebulæ of Lyra has been discovered to be a mighty galaxy, with parts of its stars attached to its mass in irregular filaments or

streams. A spiral nebulæ has been discovered in the *Dog's-Ear*, so strange and complex, that there is nothing to which it can be likened except a scroll gradually unfolding, or the evolution of a gigantic shell. Some of those nebulæ which formerly appeared as nearly circular masses, have now been descried to have numerous luminous filaments streaming out in every direction, and interwoven with streams of stars. Even the great nebulæ of Orion, which no former telescope could resolve, has been surveyed by Lord Rosse, who has no doubt of its resolvability, having plainly seen a mass of stars about the trapezium, and the characteristics of resolvability in other parts strongly marked. Sir J. South remarks, that when observing with this telescope, he saw nebulæ, amounting to thirty or more, "the most of which the telescope removed from the list of nebulæ, where they had long figured, to that of *clusters;* while some of these latter, more especially the fifth of Messier, exhibited a sidereal picture such as man never before had seen, and which, for its magnificence, baffles all description."—There has not yet been sufficient time or opportunity for exploring the wonders of the planetary and starry regions with this instrument, but it has already expanded our views of the grandeur of the sidereal heavens, and of the boundless extent of that Empire which stretches into infinity, and in the course of time it will, doubtless, be the mean of disclosing to our view scenes and objects which have never yet been anticipated. This instrument—the construction and erection of which cost the Earl of Rosse no less than £12,000—reflects the highest honour on the genius, the inventive powers, and the scientific acquirements of its noble contriver, and will perpetuate his Lordship's name to future generations, in company with Tycho, Galileo, Herschel, and other illustrious astronomers, who have enriched the science of the heavens with their inventions and labours.[1]

The Microscope.

The *Microscope* is another instrument, constructed on similar principles, which has greatly expanded our views of the "manifold wisdom of God." This instrument, which discovers to us small objects invisible to the naked eye, was invented soon after

[1] For a more detailed account of this telescope, as well as a practical description of *all kinds of telescopes*, the reader is referred to the Author's Work entitled "The Practical Astronomer."

the invention and improvement of the telescope. By means of this optical contrivance, we perceive a variety of wonders in almost every object in the animal, the vegetable, and the mineral kingdoms. We perceive that every particle of matter, however minute, has a determinate form—that the very scales on the skin of a haddock are all beautifully interwoven and variegated, like pieces of network, which no art can imitate—that the points of the prickles of vegetables, though magnified a thousand times, appear as sharp and well polished as to the naked eye—that every particle of the dust on a moth or a butterfly's wing is a beautiful and regularly organized feather—that every hair of our head is a hollow tube, with bulbs and roots, furnished with a variety of threads and filaments—and that the pores in our skin, through which the perspiration flows, are so numerous and minute, that a grain of sand would cover a hundred and twenty-five thousand of them. We perceive animated beings in certain liquids, so small that fifty thousand of them would not equal the size of a mite; and yet each of these creatures is furnished with a mouth, eyes, stomach, blood-vessels, and other organs for the performance of animal functions. In a stagnant pool which is covered with a greenish scum during the summer months, every drop of the water is found to be a world teeming with thousands of inhabitants. The mouldy substance which usually adheres to damp bodies, exhibits a forest of trees and plants, where the branches, leaves, and fruit, can be plainly distinguished. In a word, by this admirable instrument we behold the same Almighty hand which rounded the spacious globe on which we live, and the huge masses of the planetary orbs and directs their rapid motions through the sky,—employed, at the same moment, in rounding and polishing ten thousand minute transparent globes in the eye of a fly; and boring and arranging veins and arteries, and forming and clasping joints and claws, for the movements of a mite! We thus learn the admirable and astonishing effects of the Wisdom of God and that the Divine Care and Benevolence are as much displayed in the construction of the smallest insect, as in the elephant or the whale, or in those ponderous globes which roll around us in the sky. These, and thousands of other views which the microscope exhibits, would never have been displayed to the human mind had they not been opened up by this admirable invention.

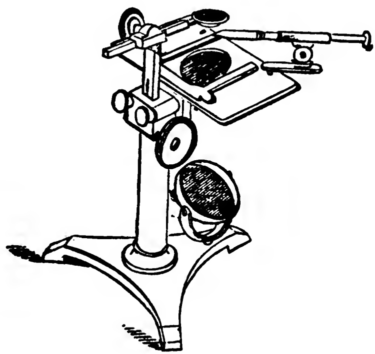
In fine, by means of the two instruments to which I have now adverted, we behold Jehovah's empire extending to infinity on either hand. By the telescope we are presented with the most astonishing displays of his *omnipotence*, in the immense number, the rapid motions and the inconceivable magnitude of the celestial globes;—and by the microscope, we behold, what is still more inconceivable, a display of his unsearchable wisdom in the Divine mechanism, by which a drop of water is peopled with myriads of inhabitants—a fact, which, were it not subject to ocular demonstration, would far exceed the limits of human conception or belief. We have thus the most striking and sensible evidence, that, from the immeasurable luminaries of heaven, and from the loftiest seraph that stands before the throne of God, down to this lower world, and to the smallest microscopic animalcule that eludes the finest glass—He is everywhere present, and, by his power, intelligence, and agency, animates, supports, and directs the whole. Such views and contemplations naturally lead us to advert to the character of God, as delineated by the sacred writers, that "He is of great power and mighty in strength;" that "His understanding is infinite;" that "His works are wonderful;" that "His operations are unsearchable and past finding out;" and they must excite the devout mind to join with fervour in the language of adoration and praise—

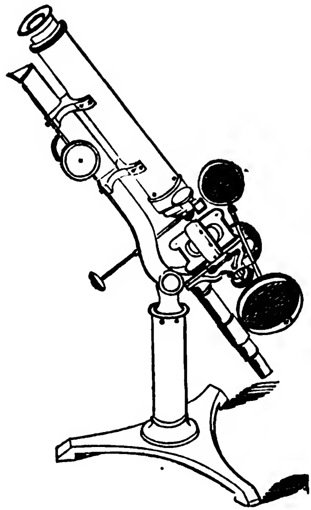
> When thy amazing works, O God!
> My mental eye surveys,
> "Transported with the view, I'm lost
> In wonder, love, and praise."

The microscope was invented a few years after the invention of the telescope. Different persons have laid claim to this invention. *Drebell*, a Dutchman, is said to have been among the first who constructed a microscope, about the year 1621, about twelve years after Galileo had constructed his telescope. Borelli, in his history of inventions, is of opinion that it was invented by *Junsen*, one of the reputed contrivers of the telescope. The instruments which he constructed are said to have been about six feet in length, and the tube of gilt copper, one inch in diameter, supported by brass pillars in the shape of dolphins. Of the internal construction of such microscopes we have no precise account.—There

are now three or four different kinds of microscopes occasionally used.

(1.) The *Single Microscope.* This microscope consists of a single lens, or convex glass. The magnifying power of such lenses depends upon their focal distances. Supposing the distance at which the eye can perceive near objects distinctly to be eight inches —if we view a near object with a convex glass two inches focal distance the eye may be brought within two inches of the object, and its length and breadth, or its diameter, will appear four times larger than when viewed by the naked eye. If the focus of the glass be one inch, the magnifying power will be eight times; if one-fourth inch, thirty-two times; if one-tenth inch, eighty times; if one-twentieth of an inch, 160 times, because eight inches divided by one-twentieth produces a quotient of 160, and as the object is magnified every way in length as well as in breadth, we must square these numbers in order to ascertain how much the object is really enlarged. Thus we find that a lens one-twentieth of an inch focus, magnifies the superficies of objects no less than 25,600, or twenty-five thousand, six hundred times. It was with such microscopes that the famous *M. Leeuwenhoek* made most of his microscopical discoveries, with single lenses of this description with short foci. The small convex glass was set in a socket between two silver plates riveted together, and pierced with a small hole; and the object was placed on the point of a needle. Some very small and powerful lenses have been formed of the *diamond,* by Dr. Goring, and Mr. Pritchard, optician, London. These lenses have been made as small as one-sixtieth of an inch focal distance, which magnify minute objects, 230,400, or two hundred and thirty thousand, four hundred times.


THE SINGLE MICROSCOPE.



THE COMPOUND MICROSCOPE.

(2.) The *Compound Microscope.* This instrument consists of two or more convex lenses,—one next the object, by which an enlarged image of the object is formed, and another next the eye, by which a magnified representation of the enlarged image is obtained. The object glass is generally of a short focal distance, about a half, or three-quarters of an inch. The eye glass may be about one or one-and a-half inch, and their distance about four or five inches. There are no other glasses *essentially* necessary; but in order to enlarge the field of view, two and sometimes three glasses are placed next the eye. For a particular and practical description of this kind of microscope, the reader is referred to the author's volume, entitled 'The Improvement of Society by the Diffusion of Knowledge,'—and from the description there given, which is accompanied with engravings—any common mechanic may be enabled to construct a compound microscope at a very small expence.

(3.) The *Solar Microscope.* This microscope can only be used in a darkened chamber and when the sun shines. It consists of a tube, a looking glass, a convex lens to condense the sun's rays upon the object, and a convex glass of a short focal distance to throw the magnified image of the object on a white screen, or a large sheet of white paper. The looking glass is placed on the outside of the window of a darkened room, and by a motion performed in the inside of the window, the sun's rays are directed through the tube to illuminate the object. The convex glass which throws the image on the sheet may be about half an inch focus, and the distance between it and the sheet may be five or six feet. The greater the distance of the screen, the larger the object will appear, but there is a certain medium distance at which the object will appear most distinct. In this way a flea, or any

similar insect, may be magnified to the length of five or six feet, so as to appear nearly as large as an ox; but it is generally more distinct when not enlarged to above half this size. The eels in paste and in sour vinegar may thus be exhibited nearly a foot in length, with all their motions. By this microscope a whole company may be entertained at once, and the weakest eyes may look upon the object without straining or fatigue.—On the same principle is the OXY-HYDROGEN microscope, exhibited in various Lecture rooms, constructed; only, instead of the sun's rays, there is the application of a brilliant jet of oxy-hydrogen gas, acting on a ball or cylinder of lime, which produces the most intense light. With this microscope, which can be used either by day or by night, small animals and animalcules—when connected with some fibres of vegetable substance—present a most striking and splendid appearance, when displaying all their motions on a screen of forty feet in diameter.

Besides the above stated microscopes there are likewise the *lucernal* microscope, which is used with the Argand lamp, the images of objects being refracted from a single lens, upon one or two large convex lenses, of five inches or upwards in diameter—the *reflecting* microscope, composed both of lenses and specula, and several others. The most eligible instrument, on the whole, for common use, is the compound microscope, as it takes in a large field of view, and does not strain the eye so much as the small lenses of single microscopes; and one of considerable magnifying power can be constructed by a private individual at a small expence.

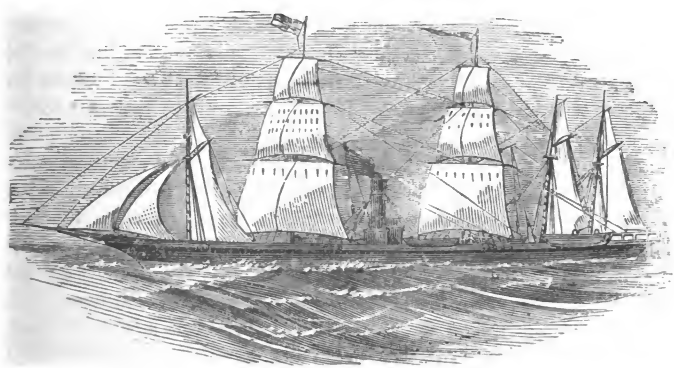
Steam Navigation.

We might have been apt to suppose that the chemical experiments that were first made to demonstrate the force of *Steam* as a mechanical agent could have little relation to the objects of Religion, or even to the comfort of human life and society. Yet it has now been applied to the impelling of ships and large boats along rivers and seas, in opposition to both wind and tide, and with a velocity which at an average exceeds that of any other mode of conveyance by water. And we have no reason to believe that this invention has hitherto attained its highest state of perfection; but that it is still susceptible of such improvements, both

in point of expedition and of safety, as may render it by far the most comfortable and speedy conveyance between distant lands, for transporting the volume of inspiration and the heralds of the gospel of peace to "the ends of the earth." By the help of his compass, the mariner is enabled to steer his course in the midst of the ocean, in the most cloudy days and in the darkest nights, and to transport his vessel from one end of the world to another. It now only remains that navigation be rendered safe, uniform, and expeditious, and not dependent on adverse winds or the currents of the ocean; and there is every reason to expect, as the art of propelling vessels by the force of steam proceeds towards perfection, that these desirable objects will be fully attained. Even at present, as the invention now stands, were a vessel, fitted to encounter the waves of the Atlantic, constructed of a proper figure and curvature, with a proper disposition of her wheels, and having room where fuel can be stowed in sufficient quantity for the voyage, at the rate of ten miles an hour, she would pass from the shores of Britain to the coast of America in less than eight days; —and, even now, the voyage can be completed in little more than ten days: so that intelligence might pass and repass between the eastern and western continents within the space of a single month —a space of time very little more than was requisite, eighty years ago, for conveying intelligence between Glasgow and London. The greatest distance at which any two places on the globe can lie from each other is about 12,500 miles; and therefore, if a direct portion of water intervene between them, this space could be traversed in fifty-four or sixty days. And, if the isthmus of Panama which connects North and South America, and the isthmus of Suez, which separates the Mediterranean from the Red sea, were cut into wide and deep canals, (which we have no doubt will be accomplished as soon as civilized nations have access to perform operations in these territories; indeed, a railroad across the Isthmus of Panama is now in operation, the fruits of American enterprise and ingenuity) every country in the world could then be reached from Europe in nearly a direct line; or, at most, by a gentle curve, instead of the long and dangerous and circuitous route which must now be taken, in sailing for the eastern parts of Asia and the north-western shores of America. By this means, eight or nine thousand miles of sailing would be saved in a voyage from England to Nootka Sound, or the Peninsula of Cali-

fornia; and more than six thousand miles in passing from London to Bombay in the East Indies; and few places on the earth would be farther distant from each other by water than 15,000 miles; which space might be traversed in a period of about fifty days.

When the first edition of this work was published, these anticipations were scarcely expected to be realized, at least in the present age. It is but within the last few years that one of our most distinguished philosophers and engineers, Dr. Lardner, denounced the scheme of attempting to cross the Atlantic by means of steam, as an enterprise altogether impracticable. But the navigation of the Atlantic, by means of steam-vessels, for several years past, has been regular and almost as common as with ordinary sailing vessels;—and the rate of motion has been even greater than we anticipated. The *Great Western* was among the first steam-vessels that crossed the Atlantic from Britain to America, in 1838, and



THE GREAT BRITAIN STEAMER.

accomplished the voyage in safety in about thirteen days, having on board above a hundred passengers. Since that period many other vessels have regularly performed voyages to and from the shores of America and Great Britain, and, except in the case of the *President* and the *Artic*, they have all been accomplished without any serious accidents,—so that the practicability and the utility of steam navigation across the ocean may now be considered as fully established. Voyages by steam are now likewise regularly performed

to Lisbon, Cadiz, and along the Mediterranean, as far as Alexandria, and from Bombay to Suez along the Arabian and the Red sea —and at this moment almost every sea and ocean on the surface of the globe is traversed by steam-vessels, promoting a rapid intercourse between all the nations, tribes, and families of the earth. —The rate of motion at which such vessels are impelled across the Atlantic may be deduced from the following facts. The first voyage of the *Britannia*, which sailed on the 4th July, 1840, from Liverpool to Halifax, was accomplished in twelve days, ten hours; and her return homeward occupied only ten days. The outward voyage of the *Columbia*, which sailed from Liverpool, May 19th, 1842, was performed in eleven days, twenty-two hours; and her voyage home from Halifax in nine days, seventeen hours. It thus appears that intelligence may now pass and repass between Britain and the continent of America in twenty-three or twenty-four days, or little more than three weeks; so that it is possible a person might receive an answer to a communication sent to America in less than three and a half weeks. At this rate, 15,000 miles—or the greatest distance between any two places on the globe by water, might be traversed in about fifty days. Steamers are now regularly employed in the Indian and Australian passenger trades.[1]

But we have reason to believe, that when this invention, combined with other mechanical assistances, shall approximate nearer to perfection, a much more rapid rate of motion will be effected; and the advantages of this, in a religious as well as in a commercial point of view, may be easily appreciated; especially at the present period, when the Christian world, now aroused from their slumbers, have framed the grand design of sending a Bible to every inhabitant of the globe. When the empire of the Prince of Darkness shall be shaken throughout all its dependencies, and the nations aroused to enquire after light and liberty and divine knowledge—intelligence would thus be rapidly communicated over every region, and between the most distant tribes. "Many would run to and fro, and knowledge would be encreased." The ambassadors of the Redeemer, with the Oracles of Heaven in their hands, and the words of salvation in their mouths, would quickly be transported to every clime, "having the everlasting gospel to preach to every nation and kindred and tongue and people."

1 See Appendix.

Since the above paragraphs were first written, Steam navigation has extended its influence throughout all the kingdoms and States of Europe and America, and its beneficial effects are experienced even on the coasts and rivers of Asia and Africa. A most striking contrast is now presented between the rate of sailing and the voyages performed in the present day, from what they were only two centuries ago. About that time, and even later, a Dutch ship performed the voyage to America, by leaving Rotterdam or Amsterdam in the spring one year, sailing only during the day, and furling her sails and laying-to during the night; and, on reaching New York, this ship was discharged, unrigged, and laid up for the winter. On the following spring this ship was rigged, her condition examined and repaired, then laden with wool, fish, and furs, and then made her homeward voyage during the summer, as slowly as her outward voyage was performed the preceding year. The voyage was afterwards performed out and home the same year. English ships then made two voyages during the year; and growing bolder, three voyages to and from America, were made annually by the same ship. Those splendid vessels, the Liverpool and New York line of sailing packets were then established, and then the intercourse between Europe and America began to astonish the world.—Steam ships of a great size have now partly supplanted these packets, at least in the carriage of passengers. The space between the new and the old world now ceases to be calculated by miles and leagues; days and hours now measure the distance. Liverpool and Halifax are brought within ten days, and Liverpool and Boston, within twelve days of each other.

The states of Continental Europe are now advancing in the acquisition of steam power. France, Austria, and Russia are among the foremost in the number of their steam ships. Austria excels all the states of the Continent in merchant steam ships,—France and (till lately) Russia, in steam ships of war. The Italian states, especially Naples and Tuscany, possess several well-built, and well-navigated steam ships. Prussia and Holland, on the Rhine, contribute greatly to the facility of intercourse. The Hanseatic Towns, Denmark, and Sweden, also possess steam ships, though on a comparatively small scale. The Turks and Greeks are far behind other nations in this respect; but the Ruler of Egypt has made extraordinary advance in the acquisition of powerful steam ships.—Great Britain, on the whole, has encreased

the benefit of steam navigation throughout a wider range than any other nation on the Eastern Continent.

In 1814 there was but one steam boat belonging to the British Empire. During forty years, the number has encreased to about *one thousand five hundred* steam vessels, which are now navigating all parts of the world.—In 1856, the British Government employs a magnificent fleet of steam ships, managed by private associations, which sail weekly between Liverpool, Halifax, Boston, and New York—the great means of intercourse by steam boats and railroads, diverges to all parts of North America—extending to the farthermost of the great Lakes, and up and down the navigable rivers, flowing from the Rocky Mountains.

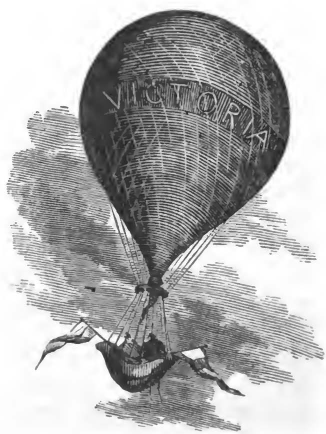
Another splendid fleet of steam ships are employed by the Government to maintain a monthly intercourse between the United Kingdom, by Southampton, and all the islands of the West Indies, and the States of Mexico and South America.—A third and mighty fleet, belonging to a great company and employed by the Government, sails monthly from Southampton to the European Peninsula, and by way of Gibraltar to Malta and Alexandria, with a branch to the Levant and Constantinople. This Company conveys the government mails and passengers by four of the most powerful steam ships in the world, from Suez, down the Red sea, to Ceylon, Madras, and Calcutta; and this Company has likewise contracted to extend the established chain between Southampton and India, to Australia, Singapore, and the Chinese Empire, by the employment of powerful steam ships. The steam line between England and Australia is now complete, by which English newspapers printed in Melbourne have been read in London only sixty days after their date.—We need scarcely mention that Steam navigation is extensively carried on, along all the coasts and rivers of the United States, and along the river St. Lawrence, and the great Lakes of British America. As steam navigation had its origin in that country, so it doubtless excels most other countries in the number of its steamers, and the extent of its coast and inland navigation. Steam has also been extensively employed in Her Majesty's Navy during the late Russian war.

By means of the powerful agency now at work in the conducting of steam navigation, and the rapidity with which intercourse with the remotest nations is now accomplished—trade and commerce may be extended to every land, and the productions of

every climate, in a short time, conveyed from one continent to another. The bonds of Brotherhood among the great family of mankind will be strengthened; the circumstances which have led to alienation and hatred will be gradually removed; the spirit of warfare, and the causes which have produced the hostility of nations will be subverted; the productions which one country requires from another will be mutually and amicably exchanged; civilization will be advanced; knowledge of every description will be extended; "the wilderness and solitary places" of the globe will be cultivated and peopled; the tribes of the heathen world gradually enlightened and christianized; and the way prepared for the approach of the long-expected and peaceful millennium, when "wars shall cease to the ends of the earth," and the nations "shall delight themselves in an abundant peace."

Balloons.

Similar remarks may be applied to the *invention of balloons.* We have heard of some pious people who have mourned over such inventions, and lamented the folly of mankind in studying their construction and witnessing their exhibition. Such dispositions generally proceed from a narrow range of thought and a contracted view of the Divine economy and arrangements in the work of redemption. Though the perversity of mankind has often applied useful inventions to foolish and even to vicious purposes, yet this forms no reason why such inventions should be descried; otherwise the art of printing and many other useful arts might be regarded as inimical to the human race. We have reason to believe that air balloons may yet be brought to such perfection as to be applied to purposes highly beneficial to the pro-



THE BALLOON.

gress of the human mind, and subservient, in some degree, for effecting the purposes of Providence in the enlightening and renovation of mankind. For this purpose, it is only requisite that some contrivance, on chemical or mechanical principles, be suggested, analogous to the sails or rudder of a ship, by which they may be moved in any direction, without being directed solely by the course of the wind; and there can be little doubt that such a contrivance is *possible* to be effected. It requires only suitable encouragement to be given to ingenious experimental philosophers, and a sufficient sum of money to enable them to prosecute their experiments on an extensive scale. To the want of such prerequisites it is chiefly owing that the hints on this subject, hitherto suggested, have either failed of success or have never been carried into execution. A more simple and expeditious process for filling balloons has lately been effected—the use of the *parachute*, by which a person may detach himself from the balloon and descend to the earth, has been successfully tried,—the lightning of heaven has been drawn from the clouds, and forced to act as a mechanical power in splitting immense stones to pieces,—the atmosphere has been analyzed into its component parts, and the wonderful properties of the ingredients of which it is composed exhibited in their separate state; and why then should we consider it as at all improbable that the means of producing a horizontal direction in aerial navigation may soon be discovered? Were this object once effected, balloons might be applied to the purposes of surveying and exploring countries hitherto inaccessible, and of conveying the messengers of divine mercy to tribes of our fellow-men whose existence is as yet unknown.

We are certain that every portion of the inhabited world must be thoroughly explored, and its inhabitants visited, before the salvation of God can be carried fully into effect; and for the purpose of such explorations, we must of course resort to the inventions of human genius in art and science. Numerous tribes of the sons of Adam are doubtless residing in regions of the earth with which we have no acquaintance, and to which we have no access by any of the modes of conveyance presently in use. More than one half of the interior parts of Africa and Asia, and even of America, are wholly unknown to the inhabitants of the civilized world. The vast regions of Chinese Tartary, Thibet, Siberia, and the adjacent districts; the greater portion of Africa

and the continent of Australia; the extensive isles of Bornea, Sumatra, New Guinea, and Japan, the territory of the Amazons, and the internal parts of North and South America, remain for the most part unknown and unexplored, though recent conventions have opened the trade of the Japan peninsula to European and American enterprise. The lofty and impassable ranges of mountains, and the deep and rapid rivers, which intervene between us and many of those regions, together with the savage and plundering hordes of men and the tribes of ravenous beasts through which the traveller must push his way—present to European adventurers barriers which they cannot expect to surmount, by the ordinary modes of conveyance, for a lapse of ages. But, by balloons constructed with an apparatus for directing their motions, all such obstructions would at once be surmounted. The most impenetrable regions, now hemmed in by streams and marshes and lofty mountains, and a barbarous population, would be quickly laid open; and cities and nations, lakes and rivers, and fertile plains, to which we are now entire strangers, would soon burst upon the view. And the very circumstance that the messengers of peace and salvation *descended upon such unknown tribes from the region of the clouds*, might arouse their minds and excite their attention and regard to the message of divine mercy which they came thither to proclaim. Such a scene (and it may probably be realized) would present a literal fulfilment of the prediction of "*angels flying through the midst of*" the aerial "*heaven*, having the everlasting Gospel to preach to them that dwell upon the earth, and to every kindred and nation."

In this point of view, we cannot but feel the most poignant regret at the conduct of the Spaniards, after the discovery of America, towards the natives of that country. When those untutored people beheld the ships which had conveyed Columbus and his associates from the eastern world, the dresses and martial order of his troops, and heard their music and the thunder of their cannon, they were filled with astonishment and wonder at the strange objects presented to their view; they fell prostrate at their feet, and viewed them as a superior race of men. When *Cortez* afterwards entered the territories of Mexico, the same sentiments of reverence and admiration seemed to pervade its inhabitants. Had pure Christian motives actuated the minds of these adventurers, and had it been their ruling desire to communicate

to those ignorant tribes the blessings of the Gospel of peace, and to minister to their external comfort, the circumstance now stated would have been highly favourable to the success of missionary exertion, and would have led them to listen with attention to the message from heaven. But, unfortunately for the cause of religion, treachery, lust, cruelty, selfishness, and the cursed love of gold, predominated over every other feeling, affixed a stigma to the Christian name, and rendered them curses instead of blessings to that newly discovered race of men. It is most earnestly to be wished that, in all future expeditions in quest of unknown tribes, a few intelligent and philanthropic missionaries may be appointed to direct the adventurers in their moral conduct and intercourse with the people they visit, in order that nothing inconsistent with Christian principle make its appearance. The uniform manifestation of Christian benevolence, purity, and rectitude, by a superior race of men, would win the affections of a rude people far more effectually than all the pomp of military parade.

Of late years, the attention of several scientific persons has been directed to the improvement of aerial navigation, and it is the opinion of many that the problem of giving to balloons a horizontal direction has been in some measure solved. About the year 1837 some plans of this description were laid before a committee of the Royal Society, and an association was attempted to be formed for exploring the continent of Africa by means of a large balloon which was to be constructed for this special purpose; but after the projectors had proceeded a certain length, the scheme was allowed to drop, for want of patronage and support. In the year 1840, Mr. Green, the most celebrated aëronaut of modern times, who has performed several hundreds of aërial voyages, proposed making a voyage in a balloon from the American to the European continent, across the Atlantic; but the idea was eventually abandoned on account of the difficulties that presented themselves. Several balloon ascents were, however, made as recently as 1853, from various points in Europe, with a view to ascertain the temperature at certain fixed heights above the earth's surface; and in this way scientific men at last discovered a real *use* for what had hitherto been only a philosophical toy!

As the invention now stands, the balloon, under the direction of such an experienced aëronaut as Mr. Green, might be rendered subservient to many important purposes, particularly in taking a

general survey of unknown countries. Suppose a balloon, properly equipped for the purpose, were to be elevated either on the eastern or western shores of Africa, so as to pass nearly over the central parts of that continent,—by taking advantage of the monsoons, or trade-winds, which blow for a certain period in the same direction—the general aspect and character of this country, with which we are at present so little acquainted, might be laid open to view, at least as to its more prominent and general features. The extent of its lakes—the direction and magnitude of its rivers—the ranges of mountains with which it is diversified—its deserts, forests, and cultivated fields—the positions and magnitude of its cities—the characteristics of its inhabitants, and the probable amount of population—with several other particulars—might all be deduced by an intelligent aeronaut, when passing across such a country at a proper elevation, besides having an opportunity of performing a variety of electric, magnetic, and other scientific experiments, for enlarging our knowledge of the principles and processes of nature. In the same manner the Chinese Empire—of which we know so little—might be extensively surveyed, and our knowledge of that interesting and populous region of the globe rendered more definite and expansive. In both these cases, and several others, the course of the periodical winds might be rendered subservient to the success of the enterprise.

Should any one be disposed to insinuate, that the views now stated on this subject are chimerical and fallacious, I beg leave to remind him, that not more than forty years ago, the idea of a large vessel, without oars or sails, to be navigated against the wind with the rapidity of twelve miles an hour, would have been considered as next to an impossibility, and a mere fanciful scheme, which could never be realized. Yet we now behold such vehicles transporting whole villages to the places of their destination, with a degree of ease, comfort, and expedition, formerly unknown, and even crossing in safety the wide Pacific ocean. And little more than sixty years have elapsed, since it would have been viewed as still more chimerical to have broached the idea, that a machine might be constructed, by which human beings might ascend more than two miles above the surface of the earth, and fly through the regions of the clouds at the rate of seventy miles an hour, carrying along with them books, instruments, and provisions. Yet both these schemes have been fully realized, and, like many other inventions of the

human intellect, are doubtless intended to subserve some important ends in the economy of divine Providence.

Balloons were first constructed in the year 1783, by Messrs. S. & J. Montgolfier, paper manufacturers at Annonay, in France. A sheep, a cock, and a duck, were the first animals ever carried up into the air by these vehicles. At the end of their journey, they were found perfectly safe and unhurt, and the sheep was even feeding at perfect ease. The first *human* being who ascended into the atmosphere in one of these machines, was M. Pilatre de Rozier. This adventurer ascended from amidst an astonished multitude assembled in a garden in Paris, on the 15th October, 1783, in a balloon, whose diameter was forty eight feet, and its height about seventy four; and remained suspended above the city about four hours. M. Lunardi, an Italian, soon after astonished the people of Scotland and England, by his aerial excursions, Dr. G. Gregory gives the following account of his first ascent:—"I was myself a spectator of the flight of Lunardi, and I never was present at a sight so interesting and sublime. The beauty of the gradual ascent, united with a sentiment of terror on account of the danger of the man, and the novelty and grandeur of the whole appearance, are more than words can express. A delicate woman was so overcome with the spectacle, that she died upon the spot as the balloon ascended; several fainted; and the silent admiration of the anxious multitude was beyond anything I had ever beheld."

Balloons have generally been made of varnished silk, and of the shape of a globe or a spheroid, (see fig. 41,) from thirty to fifty feet in diameter. They are filled with hydrogen gas, which, as formerly stated, is from twelve to fifteen times lighter than common air: and they rise in the atmosphere on the same principle as a piece of cork ascends from the bottom of a pail of water. The aërial travellers are seated in a basket below the balloon, which is attached to it by means of cords.—The *Parachute* (see fig. 39) is an invention, by which the voyager, in cases of alarm, may be enabled to desert his balloon in mid-air, and descend to the ground without injury. It resembles an umbrella, but is of far greater extent. With one of these contrivances, twenty-three feet in diameter, M. Garnerin, having detached himself from his balloon, descended from a height of more than 4000 feet, and landed without shock or accident. Several fatal accidents have, however, since taken place, and the use of the parachute has been very

properly discontinued till some better scientific assurance of their safety has been discovered.

The following representation (fig. 41). exhibits a view of Mr. Green's balloon, in which he has made so successful ascents from various places. The form of the balloon was nearly of the shape

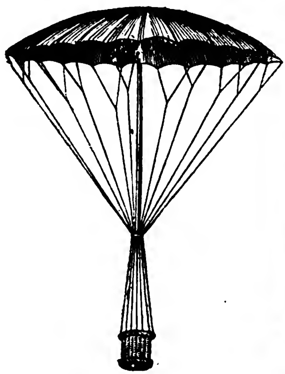


Fig. 39.

Fig. 40.

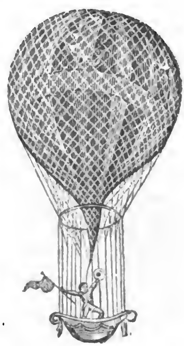


Fig. 41.

of a pear: it was composed of stripes of variegated silk; and over this was thrown an envelope of net-work, which, passing down, served as a support to the car in which the aeronaut was placed. It may give the reader who has never seen a balloon, a general idea of its form and of the mode in which aërial navigation is performed.

Figs. 39 and 40 represent the parachute of M. Garnerin, and the apparatus connected with it. In fig. 40 is shown a cylindrical box, about three feet in height and two in diameter, which was attached by a straight pole, to a truck or disc at the top, and from this was suspended a large sheet of linen somewhat similar to an umbrella. M. Garnerin stood in the box, and the form the machine assumed on his descent is shown in fig 39. When first cut from the balloon, it descended with great velocity, and those who witnessed

its progress considered his destruction inevitable; but after a few seconds, the canvas opened, and the resistance was so great that the apparatus diminished in its speed, till, on its arrival near the earth, it was not greater than would have resulted from leaping a height of two feet. The Parachute has since then been several times brought into use, but only seldom without accident.

Acoustic Tunnels.

By means of the inventions just adverted to—when brought to perfection, mankind may be enabled to transport themselves to every region of the globe, with a much greater degree of rapidity than has hitherto been attained. By the help of the microscope, we are enabled to contemplate the invisible worlds of life, and by the telescope we can penetrate into regions far beyond the range of the unassisted eye. By the arts of Writing and Printing we can communicate our sentiments, after a certain lapse of time, to every quarter of the world. In the progress of human knowledge and improvement, it would obviously be of considerable importance, *could we extend the range of the human voice*, and communicate intelligence to the distance of a thousand miles, in the course of two or three hours; or could we hold an occasional conversation with a friend at the distance of twenty or thirty miles. From experiments which have lately been made, in reference to the conveyance of sound, we have some reason to believe that such objects may not be altogether unattainable. It has been long known that wood is a good conductor of sound. If a watch be laid on the one end of a long beam of timber, its beating will be distinctly heard, on applying the ear to the other end, though it could not be heard at the same distance through the air. In 'Nicholson's Philosophical Journal', Mr. E. Walker describes a simple apparatus, connected with a speaking trumpet, by means of which, at the distance of seventeen and a half feet, he held a conversation with another in whispers, too low to be heard through the air at that distance. When the ear was placed in a certain position, the words were heard as if they had been spoken by an invisible being within the trumpet. And what rendered the deception still more pleasing, the words were more distinct, softer, and more musical, than if they had been spoken through the air.

About the year 1750, a merchant of Cleves, named Jorissen, who had become almost totally deaf, sitting one day near a harpsichord while some one was playing, and having a tobacco-pipe in his mouth, the bowl of which rested accidentally against the body of the instrument, he was agreeably and unexpectedly surprised to hear all the notes in the most distinct manner. By a little reflection and practice, he again obtained the use of this valuable sense: for he soon learned—by means of a piece of hard wood, one end of which he placed against his teeth, while another person placed the other end on his teeth,—to keep up a conversation, and to be able to understand the least whisper. In this way, two persons who have stopped their ears may converse with each other, when they hold a long stick or a series of sticks, between their teeth, or rest their teeth against them. The effect is the same, if the person who speaks rests the stick against his throat or his breast, or when one rests the stick which he holds in his teeth against some vessel into which the other speaks; and the effect will be the greater the more the vessel is capable of tremulous motion. These experiments demonstrate the facility with which the softest whispers may be transmitted. Water, too, is found to be a good conductor of sound. Dr. Franklin assures us, that he has heard under water at the distance of half a mile, the sound of two stones struck against each other. It has also been observed, that the velocity of sound is much greater in solid bodies than in the air. By a series of experiments, instituted for the purpose of determining this point, Mr. Chladni found that the velocity of sound, in certain solid bodies, is sixteen or seventeen times as great as in air.

But what has a more particular bearing on the object hinted at above is the experiments lately made by M. Biot, "on the transmission of sound through solid bodies, and through air, in very long tubes." These experiments were made by means of long cylindrical pipes, which were constructed for conduits and aqueducts, to embellish the city of Paris. With regard to the *velocity* of sound, it was ascertained that "its transmission through cast iron is ten-and-a-half times as quick as through air. The pipes by which he wished to ascertain at what distance sounds are audible were 1039 yards, or nearly five furlongs in length. M. Biot was stationed at the one end of this series of pipes, and Mr. Martin, a gentleman who assisted in the experiments, at the other. They heard the lowest voice, so as perfectly to distinguish the words,

and to keep up a conversation on all the subjects of the experiments. "I wished," says M. Biot, "to determine the point at which the human voice ceases to be audible, but could not accomplish it: words spoken as low as when we whisper a secret in another's ear were heard and understood; so that not to be heard, there was but one resource, that of not speaking at all.—This mode of conversing with an invisible neighbour is so singular, that we cannot help being surprised, even though acquainted with the cause. Between a question and answer, the interval was not greater than was necessary for the transmission of sound. For Mr. Martin and me, at the distance of 1039 yards, this time was about five-and-a-half seconds." Reports of a pistol fired at one end occasioned a considerable explosion at the other. The air was driven out of the pipe with sufficient force to give the hand a smart blow, to drive light substances out of it to the distance of half a yard, and to extinguish a candle, though it was 1039 yards distant from the place where the pistol was fired. Don Gautier, the inventor of the Telegraph, suggested also the method of conveying articulate sounds to a great distance. He proposed to build horizontal tunnels, widening at the remoter extremity, and found that at the distance of 400 fathoms, or nearly half a mile, the ticking of a watch could be heard far better than close to the ear. He calculated, that a series of such tunnels would convey a message 900 miles in an hour.

From the experiments now stated, it appears highly probable that sounds may be conveyed to an indefinite distance. If one man can converse with another at the distance of nearly three quarters of a mile, *by means of the softest whisper*, there is every reason to believe that they could hold a conversation at the distance of thirty or forty miles, provided the requisite tunnels were constructed for this purpose. The latter case does not appear more wonderful than the former. Were this point fully determined by experiments conducted on a more extensive scale, a variety of interesting effects would follow, from a practical application of the results. A person, at one end of a large city, at an appointed hour, might communicate a message, or hold a conversation with his friend, at another; friends in neighbouring, or even in distant towns, might hold an occasional correspondence by articulate sounds, and recognize each other's identity by their tones of voice. In the case of sickness, accident, or death, intelligence could thus

be instantly communicated, and the tender sympathy of friends immediately exchanged. A clergyman sitting in his own room in Edinburgh, were it at any time expedient, might address a congregation in Musselburgh, or Dalkeith, or even in Glasgow. He might preach the same sermon to his own church, and the next hour to an assembly at forty miles distant. And surely there could be no valid objection to trying the effect of an *invisible preacher* on a Christian audience. On similar principles, an apparatus might be constructed for augmenting the strength of the human voice, so as to make it extend its force to an assembled multitude, composed of fifty or a hundred thousand individuals; and the utility of such a power, when the mass of mankind are once thoroughly aroused to attend to rational and religious instruction, may be easily conceived. In short, intelligence respect ing every important discovery, occurrence, and event, might thus be communicated, through the extent of a whole kingdom, within the space of an hour after it had taken place.

Let none imagine that such a project is either chimerical or impossible. M. Biot's experiment is decisive, so far as it goes; that the *softest whisper*, without any diminution of its intensity, may be communicated to the distance of nearly three quarters of a mile; and there is nothing but actual experiment wanting to convince us, that the ordinary tones of the human voice may be conveyed to at least twenty times that distance. We are now acting on a similar principle in distributing illumination through large cities. Not above fifty or sixty years ago, the idea of lighting our apartments by an invisible substance, produced at ten miles distance, would have been considered as chimerical, and as impossible to be realized as the idea of two persons conversing together, by articulate sounds, at such a distance. It appears no more wonderful, that we should be able to *hear* at a distance of five or six miles, than that we should be enabled to *see* objects at that distance by the telescope, as distinctly as if we were within a few yards of them. Both are the effects of those principles and laws which the Creator has interwoven with the system of the material world; and when man has discovered the mode of their operation, it remains with himself to apply them to his necessities What the telescope is to the eye, acoustic tunnels would be to the ear; and thus, those senses on which our improvement in knowledge and enjoyment chiefly depends would be gradually carried to the utmost perfec-

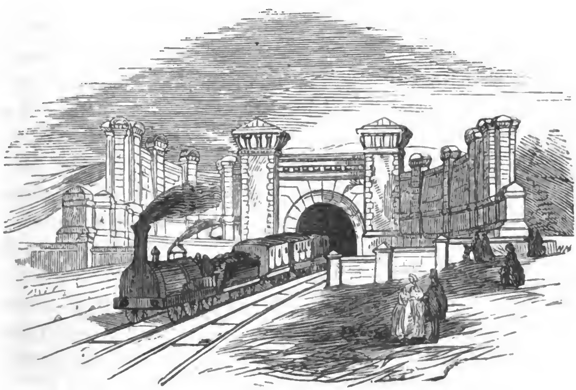
tion of which our station on earth will permit. And as to the *expence* of constructing such communications of sound, the *tenth part* of the millions of money expended in the twenty-two years' war in which we were lately engaged, would in all probability be more than sufficient for distributing them, in numerous ramifications, through the whole island of Great Britain. Even although such a project were partially to fail of success, it would be a far more honourable and useful national undertaking than that which now occupies the attention of the despots on the continent of Europe, and might be accomplished with far less expenditure either of blood or of money. Less than the fourth part of a million of pounds would be sufficient for trying an experiment of this kind, on an extensive scale; and such a sum is considered a mere *item*, when fleets and armies are to be equipped for carrying destruction through sea and land. When will the war-madness cease its rage? When will men desist from the work of destruction, and employ their energies and their treasures in the cause of human improvement? The most chimerical projects that were ever suggested by the most enthusiastic visionary, are not half so ridiculous and *degrading* to the character of man, as those ambitious and despotic schemes in which the powers of the earth in all ages have been chiefly engaged.—But on this topic it is needless to enlarge, till more extended experiments shall have been undertaken. By means of Gutta Percha tubing, however, the great end of acoustic tunnels has been in part accomplished, and it is even now quite possible to hold a conversation with a friend a quarter of a mile distant.

Railways.

The mode of travelling by means of railways, which has been introduced into Great Britain and many other countries, within the memory of most living men, is an improvement no less wonderful and beneficial to society than that of steam navigation, and promises to promote the general intercourse of mankind, and the conveyance of political and commercial intelligence to an extent and with a velocity which former ages could never have anticipated.

It appears that, so early as the year 1676, coals were carried from the mines near Newcastle-upon-Tyne to the banks of the

river, by laying rails of timber exactly straight and parallel, on which large carts with four rollers fitting the rails, and drawn by horses, could convey at once four or five chaldrons of coals. About a century afterwards, an *iron* railroad was constructed at the Sheffield colliery. But the first railway resembling those now in use, as a public thoroughfare for the conveyance of goods and passengers, was the "Stockton and Darlington Railway," which was completed only in 1825, and was the first which was attended with complete success. Several years, however, elapsed before steam



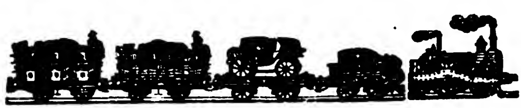
RAILWAY TRAIN AND TUNNEL.

locomotive engines were adopted. This noble triumph of art, in the swift conveyance of goods and passengers, was first practically exhibited at the opening of the "Liverpool and Manchester Railway," on the 15th September, 1830, when it was found that trains of carriages could be conveyed at the rate of twenty-five and thirty miles an hour. Since this period railways have been distributed throughout almost all the populous districts of our own and other countries.

The rails on which the wheels of the engines and carriages move are all made of iron. Each individual rail is about twelve feet in length, and six inches in depth at the two ends. Their thickness is about one inch, and the upper surface on which the wheel is to run, about two inches, so as to project laterally like the cross top of the letter T. They are pinned together at their extremities, and

are supported at intervals of every three feet, by *transverse bars of wood* sunk in the ground, called sleepers. Stone was once used for this purpose, but it was found to present too unyielding a base to the rolling of the wheels. In order to keep the wheels on the rails, they are furnished with thin edges which dip on the outside. The wheels of the locomotive have a diameter of about four feet; the diameter for the waggon or carriage-wheels is generally from thirty to thirty-six inches. The locomotive is now generally placed upon six wheels; the front and hind pair being smaller than those in the middle, these middle ones being the wheels upon which, by the action of cranks from the engine, the whole mass is propelled. A chimney rises in front and a standing place behind is allotted for the engineer who conducts and regulates the machine. The barrel-like object next the engineer consists of a furnace or fire-box, and the heat generated in it by the consumption of coke, is conducted hence through a great number of tubes in the cylinder, and finally escapes at the chimney. By means of lever handles affecting the mechanism, the engineer can at pleasure produce or stop the motion as effectually as a coach-driver could set off, or arrest the progress of his horses. Immediately behind the locomotive is a carriage called the *tender,* which is loaded with fuel, and has a tank round its sides containing water. The weight of a locomotive supplied with its proper quantity of water and fuel, is about twelve tons. When filled with water and fuel, the tender weighs about seven tons; it can carry 700 gallons of water, and eight hundred weight of coke—which will form a supply for a trip of thirty or forty miles. Larger engines and tenders are, however, sometimes used, especially on the Great Western and other *wide gauge* lines.

Fig. 42.



RAILWAY TRAIN.

The *expences* incurred in the construction and management of railways are very considerable. All inequalities of surface in the

line proposed must be removed—low parts filled up with embankments—high parts reduced—eminences which it would be impossible or too expensive to level, must be perforated by *tunnels*, and over dells and rivers viaducts require to be thrown, consisting, in some cases of numerous arches. Besides, a previous survey must be made—the land over which it has to pass must be purchased, sometimes at an exorbitant price—an act of parliament must be procured—and various petty and vexatious oppositions, arising from the avarice and obstinacy of landed proprietors, must be overcome, which not unfrequently add to all the other expences. It has been estimated that, at an average, £30,000 per mile may be considered as a moderate outlay in the construction of railways throughout most parts of Great Britain. The London and Birmingham railway—a line extending 112 miles—cost much more; its whole expence amounted to several millions of pounds. The least expensive railway we have yet heard of is that between London and Tilbury, opposite Gravesend, the average expence of which per mile is estimated not to exceed £7000.—The cost of a locomotive is about £1700, and it seldom wears longer than two years without undergoing repair. Ordinary locomotives evaporate seventy-seven cubic feet of water per hour; those on the Great Western Railway about 200 cubic feet. The evaporation of one cubic foot per hour produces a mechanical force of nearly two horse power; consequently we may ascertain the power of a locomotive by multiplying by two the number of cubic feet which it evaporates in an hour. An ordinary sized locomotive exerts a power of 150 horses; a horse upon a common road cannot draw for any length of time more than fifteen hundred weight, while on a railway it will pull with equal ease ten tons, which is thirteen times the amount; and therefore the power of a locomotive such as is usually employed is equal to a draught of 1462 tons.

The railways in most parts of Britain consist of two tracks, suitable for trains going in opposite directions; in America, Belgium, and other places, they consist generally of but one track or line of rails. On most of the lines there are *slow* trains for goods and second class passengers—*fast* trains, taking only first and second class carriages—some lines have mail trains which proceed at more than usual speed, and stop at fewer places by the way. All the carriages in a train—amounting in some cases to forty or fifty—are linked one to the other by strong iron hooks, and to prevent

them from shocks against each other, the various carriages are provided with projecting rods on springs called buffers, cushioned at the outer extremities. An improvement on the old plan of attaching carriages one to the other is the *coupling-iron*, by means of which the shock on stopping is no longer felt. From one hundred to a thousand passengers are thus conveyed, at one time, from one city or town to another; and it is a universal rule that no servant or officer of the company shall on any account take a fee from passengers, on pain of instant dismissal.

Upwards of 150 separate lines of railway have been completed in the United Kingdom of Great Britain up to 1856. The following are some of the principal lines: in England—The Liverpool and Manchester Railway, thirty-two miles in length, which cost £46,000 per mile; the London and Birmingham Railway, 112½ miles long, connecting the metropolis with the centre of England, in which are several long and expensive tunnels, and which cost above £50,000 per mile; the Grand Junction Railway, seventy nine miles in length, connecting the London and Birmingham line to that of Liverpool and Manchester, and also to a railway proceeding northward to Lancaster, which cost £21,859 per mile, forming an important thoroughfare obliquely across the country; the Manchester and Leeds Railway, fifty miles in length; the Midland Counties, North Midland and Great North of England railways, connecting the great seats of trade in Northumberland, Durham, Yorkshire, and Derbyshire, with the London and Birmingham line; the Newcastle and Carlisle Railway, sixty-one miles long; the Great Western Railway, 117 miles long, which cost £53,241 per mile, and which connects London with Bristol and with small tributary lines opening up the west of England; the Great Northern, connecting London with the north by an almost direct line; the South-Western Railway, seventy-seven miles long, connecting London with Southampton.—The principal lines in Scotland are—The Edinburgh and Glasgow Railway, about forty-six miles long, on which are several beautiful and extensive viaducts, which was opened in the beginning of 1842; the Glasgow and Ayr Railway, about forty miles long; the Glasgow, Paisley, and Greenock, twenty-two and a half miles long; the Dundee, Newtile, and Cupar-Angus railways, about seventeen miles long; the Dundee and Arbroath Railway, seventeen miles in length; and the Arbroath and Forfar Railway, fifteen miles long. A compara-

tive summary of the last published Railway Returns, (February, 1856,) shows that in the whole of the United Kingdom there were on the 30th of last June, 8115 miles of line open for traffic, against 7803 miles on the 30th of June, 1854: that 51,815,149½ passengers were conveyed thereon, against 50,367,404 in 1854; that the receipts from passengers amounted to £4,125,487 (exclusive of extra fares,) against £4,081,792 in 1854; and that the receipts from goods and cattle amounted to £5,212,865, against £4,826,825 in 1854. The grand total revenue of all railroads for the half-year was £9,894,049, against £9,424,603 in the corresponding half-year of 1854.

It appears that on the 30th of June, 1855, the following persons were employed on the railways of the United Kingdom then open for traffic—viz., 204 secretaries and managers, 33 treasurers, 140 engineers, 356 superintendents, 193 storekeepers, 181 accountants and cashiers, 823 inspectors or timekeepers, 2183 masters of stations, 322 ticket collectors, 153 draughtsmen, 7732 clerks, 1132 foremen, 3157 engine-drivers, 3488 deputy drivers or firemen, 3237 guards or breaksmen, 21,247 artificers, 2836 switchmen, 2470 gatekeepers, 1622 policemen, 14,498 porters, 7172 plate-layers, 22,449 labourers, and 2324 miscellaneous adjuncts. This makes a grand total of 97,952, against 90,409 on the 30th of June, 1854—viz., 80,877 in England, 11,403 in Scotland, and 5672 in Ireland. The length of line open for traffic was 8116 miles, and the number of stations 2798. The total number of persons employed on railroads not open, on the 30th of June, 1855, amounted to 38,546, the length of line in course of construction being 879 miles, and the total length authorised 4481. Of these 38,546 persons, 104 were secretaries, 16 treasurers, 181 engineers, 238 superintendents, 83 storekeepers, 55 accountants, 331 inspectors, 61 draughtsmen, 110 clerks, 601 foremen, 216 policemen, 47 porters, 4962 artificers, 31,370 labourers, and 171 adjuncts of no special vocation. The total number of persons employed on all railways, open or not, was, on the said 30th of June last, 136,498, against 135,810 in 1854, and of these 104,292 were employed in England, 17,388 in Scotland, and 14,818 in Ireland.

A return published on the 8th February, shows that seventy-three railway acts were passed last year—viz., twenty-three for incorporating companies, six for extension of time, &c., nine for deviations and extensions, thirteen for branches for which new

capital was required, three for reduction of capital, nine for additional capital for works before authorised, two for leases, seven for debentures, &c., and one for steamboats. The total increase of mileage thus occasioned was forty-four miles, ten chains, and the increase of capital and loan £5,253,675.

The average cost per mile of British railways is stated to be—

Cost of Land, ...	£4000
Way and Works, ...	22,000
Office and Sundries, ...	1000
Locomotive power and working Stock, .	8000
Total,	£35,000

The average cost per mile of passengers lines in America is £9000; in France £21,348; in Belgium £16,600; in Germany £10,000; and in Prussia £15,000. The profits on British railways have averaged five per cent., though three per cent is now, in consequence of increased expences arising from the war, &c., much nearer the mark; on French railways four seven-tenths per cent. The average cost of working British railways is reckoned at about 58 per cent. of the gross receipts.

It has been a question whether railways derive their traffic from the great towns usually selected as *termini*, or from the districts through which they pass. In order to a solution of this question, a writer in the Edinburgh Review has compiled the following table,

	Number of passengers.	Receipts from passengers.	Receipts per passenger.	Average fare per mile for each passenger.	Average distance travelled by each passenger.	Equivalent number of passengers carried one mile.
		£	s.	D.	Miles.	
1st Class,	5 474,160	1.516,805	0 5 7	2 6-tenths	26 7-10	142,328,238
2nd Class,	14,325,825	1 598 115	0 2 2	1 56-100ths	13½	196,263,808
3rd Class,	13,135,823	621,903	0 0 11½	1	11	147,777,975
Mixed,	855,445	209.518	0 4 11	2 3-tenths	24⅛	20,530,480
Total and Oxen.	33,791,253	3,946 341	0 3 4	1-9	18	506,900,495

in which there is a comparison made between the total number of passengers carried on the railway, with the total amount paid to them on the one hand, and the average fare per mile chargeable

to them on the other.—In the table is given the *number of passengers* of each class in the year ending 30th June, 1845—the total *amount of fare* they paid—the average paid *per passenger*—the average fare *per mile*—and the consequent average *distance* which each passenger travelled. In order to express the actual and relative amounts of passenger service recorded by the railways in that year, there is given the equivalent number of passengers of each class, and the total carried one mile.

"From the table, it is apparent, in the first place, contrary to what might be expected, that the railways derive their revenue from passengers who travel short distances, and not from those who pass between the great centres of population which mark the *termini*, and which usually give the railway its name. The first-class passengers whose excursions are the longest, tavel, on the average, only twenty-six miles, and the great majority of these must travel much less distances than even this. For one who makes a trip of 100 miles, there must be at least ten who go only ten miles, otherwise the average could not be maintained. In like manner the second-class travellers travel only thirteen miles, and the third-class eleven miles, giving twelve miles as the average of the two; and these constitute about eighty per cent. of all the passengers transported on railways. Short-passenger traffic—that is to say, trips of a dozen miles or thereabouts; these it is evident constitute the great staple of the railway business in passengers. It is clear then, that the terminal population have but little connection with the financial success of railway projects. The main support is short traffic."

Of every hundred passengers booked, there is the following proportions of the different classes; first class, sixteen and a half—second class, forty-three and a half—third class, forty. Of every hundred pounds of gross revenue, the following proportions are contributed by the different classes; first class, £40 14s.—second class, £42 16s.—third class, £16 10s.—The existence of some unwise discouragement to third-class passengers is very apparent in these numbers. Under the ordinary influences which govern personal economy, they ought to be the most numerous, if not the most productive. They are nevertheless inferior in number to the second class, and produce a revenue greatly inferior to either first or second class. The case appears to be different elsewhere. In Belgium the relative numbers of the different classes are such that of every

100 passengers there are, first class, ten—second class, thirty—third class, sixty; and or every £100 gross revenue from passengers the contribution of the respective classes is, first class, £20—second class, £33—third class, £47; so that the revenue on the Belgian lines is supplied by the second and third class, but chiefly by the third. On the English lines the third-class passengers are discouraged by four causes, brought into operation apparently with that intenion by the companies. These are, first, high fares; second, carriages uncomfortable and unsafe; third, inconvenient hours; fourth, low speed.—The Belgian fares are considerably lower than the corresponding class on the British lines—the third class is little more than the half of the third class on our railways, and the carriages for this class are started at all hours, and are protected by roofs from the weather, and from the discharge of the funnel of the engine. While these sheets are passing through the press, however, several admirable alterations are taking place. On several Scotch and English railways, the second class is being abolished altogether, and the accommodation of the third class raised, without increase of fare.

It has been calculated that the locomotive engines employed in drawing passenger trains in the year 1854-5, performed the work of 160,000 stage coach horses; and that the locomotive engine has reduced the cost of travelling to one third of its former amount.—The following instances may be stated of the difference between the *estimated* and *actual cost* of railways.

	Original Capital.	Actual cost of Line.
Liverpool and Manchester, . .	£510,000	1,774,000
London and Birmingham, . .	3,500,000	6,000,000
Birmingham and Liverpool, .	1,000,000	1,500,000

The following are some statistics in reference to the *Continental Railways.* The *number* of railways on the continent at present, in full operation, amounts to about 150. Of this number twenty-four are in France, the total length being 1140 miles; in Belgium there are sixteen, forming in point of length between 800 and 900 miles. Upon the borders of the Rhine there are thirteen railways, making a total in length of 800 miles. In Prussia and the German States there are twenty-seven railways, the length of rails being upwards of 1300 miles. In Austria, Bavaria, etc., there are fourteen rail

ways, the length being upwards of 1000 miles. In Holland only four, with a length of 150 miles; and in Italy the same number, length eighty miles; but the present Pope has projected a considerable number more, to the extent of several hundreds of miles. A railway is constructed between Moscow and St. Petersburgh, its length is above 400 miles. The only railway to be constructed in Sweden runs from the iron mines of Gelliwara in Lapland, to the port of Tonnefors, and is above eighty miles in length. These mines are the richest in Sweden; but their produce is comparatively of little value, from the difficulty which exists in carrying it to the sea.

The velocity with which railway trains generally proceed, is from 23 to 30 miles per hour; but on some of the English Railways, it is much more rapid. The lines upon which the trains travel with the greatest speed are as follows:—Average speed exclusive of stoppages—*Northern and Eastern Railway* thirty-six miles per hour; *Great Western* thirty-three; *London and Brighton* thirty; *Newcastle and North Shields* thirty; *Midland Counties* twenty-nine; *Northland* twenty-nine; *London and North-Western* twenty-nine; *Great Northern* twenty-six and a half;—At the ordinary rate of speed, a journey from London to Liverpool by the mail train—a distance of about 210 miles—is performed in about seven hours; and the journey from Edinburgh to London is accomplished in less than thirteen hours; so that a person may leave Edinburgh at nine in the morning, and take supper in London the same evening—a journey which, not long ago, occupied nearly a fortnight.

Travelling on railways is on the whole attended with less danger than in stage-coaches or any other mode of conveyance. The personal injuries and loss of life, which have occurred chiefly on the English railways, are, without almost an exception, to be attributed, either to the ignorance and carelessness of the engine drivers, or to the imprudence and recklessness of those who have been the victims of accidents. Were men of superior intelligence and prudence always employed to direct the motion of the trains, and were the public at large to attend to the restrictions and regulations prescribed in reference to railways, almost every accident might be prevented.

The following, extracted from a work by an eminent statistical writer, Freiher Von Reden, shows the comparative number of deaths in one year by railway accidents, in proportion to the

number of passengers; and in the different countries of Europe where railways have been most extensively in operation:—

	Most Favourable.	Worst Year.	Average Year.
France,	1 in 3,302,000	1 in 254,000	1 in 1,443,000
England,	1 in 947,000	1 in 167,000	1 in 399,000
Belgium,	1 in 806,000	1 in 257,000	1 in 441,000
Germany,	1 in 8,089,000	1 in 1,248,000	1 in 5,527,000

From the above table it appears that the number of deaths, in proportion to the number of persons conveyed, is greatest in England; then come Belgium, France, and Germany. From these and other tables, Von Reden concludes that the number of accidents from railways is comparatively small, and that travelling by railways is far less dangerous than by any other means of conveyance. River-bathing is considered as far more dangerous than travelling by railway. In 1843, seven, and 1844, four persons lost their lives at Berlin whilst bathing; while in the corresponding period only three persons were killed on the railways of the whole of Germany. In London alone, from 250 to 300 persons are said to be killed yearly, by being driven over or thrown out of carriages; whilst in the whole of Europe fewer persons meet their deaths on railways. It is estimated to be far more dangerous to walk on the streets of Paris than to travel on the French railways; for, according to official returns, the number of yearly deaths on the Paris streets is from 460 to 480, while the maximum of deaths on French railways was fifty-six.—It is calculated that a Diligence or Mail coach would require to run for 470 years—carrying passengers to the same amount as railways, without causing the death of a single passenger, to make good the assertion that there is not more danger in stage-coach travelling than on railways.

The subject of *Telegraphic Communication*, so intimately connected with Railways, has already been adverted to under the head of Electricity. See also *Appendix*.

The *utility* of Railway communication, when properly conducted, must be obvious to all. In a commercial country, such as ours, the rapid conveyance of goods of all descriptions from one town to another, is an object of peculiar importance. Even in agricultural districts, the formation of railroads has enabled the landed proprietor to bring to a high state of cultivation extensive districts of land which would otherwise have remained barren and useless. But such advantages are as nothing when compared with the encreased diffusion of useful knowledge which must follow from a

cheap and rapid conveyance over the British Empire, and over all those countries that have adopted similar modes of communication and transport.—Man is thus brought into juxta-position with his fellow-men; time and space are shortened, and cities a hundred miles distant may be considered as nearly adjacent, since they can be reached in the course of three or four hours. Friends, relatives, and correspondents can thus visit each other though at a distance, without much loss of time or money—communicate information, and interchange "brotherly kindness and affection." During the summer months, those confined in towns have an opportunity of taking excursions into the country for health and recreation, without any serious interference with the demands of business. Letters, newspapers, and periodicals of all descriptions, can be conveyed with a speed which, formerly, could neither have been effected nor anticipated. In certain cases, a letter may be written, sent through the Post-office, and delivered at the distance of twenty miles, in the course of a single hour. From Liverpool a letter may be despatched to London, a distance of more than 200 miles, and an answer received in the course of the same day. As ignorance, superstition, and foolish prejudices, are the companions of those who live in retired districts, and seldom go beyond the view of the smoke of their father's chimney—so, when the great body of our fellow-men have an opportunity of taking extensive excursions through the country, we may expect that their minds will be expanded, their conceptions enlarged, and their views of nature and human society rendered more definite and extensive, so that they shall be enabled to take in ideas and portions of knowledge of which they were formerly ignorant. "Many shall run to and fro, and knowledge shall be encreased." Besides, the frequent intercourse of man with his fellow-men of every grade has a natural tendency to promote friendship, esteem, and mutual affection. Civilization can alone be promoted by the frequent social intercourse of human beings; and wherever this intercourse exists, reciprocal benefits will always ensue; and such an intercourse among all ranks is now facilitated and promoted by the invention and formation of railways.

It is likewise obvious that Christianity and the Christian virtues may, by such improvements in travelling, be promoted and ex tended. "As in water face answereth to face, so doth the heart of man to man." In communicating religious instruction, admo-

nition, and reproof, or in administering comfort under affliction, in most instances the presence and countenance of a friend, and the living voice—breathing "words that burn," and which sooth or pierce the heart—generally produce a deeper or more permanent impression, where personal intercourse is obtained, than the same sentiments communicated by letter. "For as iron sharpeneth iron, so a man sharpeneth the countenance of his friend." We can also conceive many cases in which the labours of a minister of religion, and of a Christian missionary, may be greatly facilitated and rendered successful by a rapid conveyance from one place to another, and where missionary and other philanthropic associations would be more numerously attended and patronized by Christians having a cheap and expeditious conveyance to the places in which they are held. In short, were such modes of travelling introduced into every country, we should quickly hear of what is passing in all parts of the world, and learn the aspect of the Divine dispensations towards all nations; we should learn, without loss of time, the result of all the missionary enterprises which have been undertaken for the conversion and renovation of the heathen world, and be in readiness to send forth, by a speedy course, other missionaries wherever they were wanted, to spread abroad the fame of the Redeemer, and the knowledge of that Revelation which points out the way to a blessed immortality.

In the preceding sketches I have presented a few specimens of the relation which the inventions of human ingenuity bear to religious objects. I intended to have traced the same relation in several other instances: in the invention of the electrical machine, the air-pump, mills, clocks, and watches, gas-lights, chemical fumigations, inventions for preventing and alleviating the dangers of shipwreck, etc.; but as my prescribed limits will not permit further enlargement, I trust that what has been already stated will be sufficient to establish and illustrate my general position. From this subject we may learn:—

1. That the various processes of art, and the exertions of human ingenuity, are under the special direction of Him who arranges all things "according to the counsel of his will." As "the king's heart is in the hand of the Lord, and as the rivers of water, he turns it whithersoever he pleases," so all the varied schemes and movements of the human mind, the discoveries of science, and the diversified experiments of mechanics, chemists, and philo-

sophers, are directed in such channels as may issue in the accomplishment of His eternal purposes, in respect to the present and future condition of the inhabitants of our world. This truth is also plainly taught in the records of Inspiration. "Doth the ploughman plough all day to sow? Doth he open and break the clods of his ground? When he hath made plain the face thereof, doth he not cast abroad the vetches, and scatter the cummin,[1] and cast in the wheat in the principal [place], and the barley in the appointed place, and the rye in its proper place? *For his God doth instruct him to discretion, and doth teach him.* This also cometh forth from the Lord of hosts, who is wonderful in counsel, and excellent in working." Agriculture has, by most nations, been attributed to the suggestions of Deity; for "every good and perfect gift cometh down from the Father of lights." It is he who hath taught men to dig from the bowels of the earth, iron, copper, lead, silver, and gold, and to apply them to useful purposes in social life; and who hath given them "wisdom and understanding" to apply the animal and vegetable productions of nature to the manufacture of cloths, linen, muslin, and silk, for the use and the ornament of man. For "all things are of God." "Both riches and honour come from him, and he reigneth over all, and in his hand is power and might, and in his hand it is to make great, and to give strength to all." When the frame of the Mosaic Tabernacle and all its curious vessels were to be constructed, the mind of Bezaleel "was filled with the Spirit of God, in wisdom and understanding, and in knowledge, and in all manner of workmanship, to devise curious works in gold, and in silver, and in brass." And when the fabric of the New Testament Church is to be reared, and its boundaries extended, artificers of every description, adequate for carrying on the different parts of the work, are raised up, and inspired with the spirit of their respective departments—some with the spirit of writing, printing, and publishing; some with the spirit of preaching, lecturing, and catechising; some with the spirit of fortitude, to make bold and daring adventures into distant barbarous climes; and others with the spirit of literature, of science, and of the mechanical arts—all acting as pioneers "to prepare the way of the Lord," and as builders for carrying forward and completing the fabric of the Christian Church.

[1] *Vetches* is a kind of seed frequently sown in Judea, for the use of cattle; and *cummin* is the seed of a plant somewhat like fennel.

2. All the mechanical contrivances to which I have adverted, all the discoveries of science, and all the useful inventions of genius which may hereafter be exhibited, ought to be viewed as preparing the way for the *millenial era* of the Church, and as having a certain tendency to the melioration of the external condition of mankind during its continuance. We are certain, from the very nature of things, as well as from scriptural prediction, that, when this period advances towards the summit of its glory, the external circumstances of this world's population will be comfortable, prosperous, and greatly meliorated, beyond what they have ever been in the days that are past—"Then shall the earth yield her increase, and God, even our own God, shall bless us." "Then shall he give the rain of thy seed, and thou shalt sow the ground withal; and bread of the increase of the earth, and it shall be fat and plenteous: in that day shall thy cattle feed in large pastures. The oxen likewise, and the young asses that ear the ground, shall eat savoury provender, which hath been winnowed with a shovel and with the fan." "And the inhabitant shall not say, I am sick." "They shall build houses and inhabit them; and they shall plant vineyards and eat the fruit of them. They shall not build, and another inhabit; they shall not plant, and another eat: for *as the days of a tree are the days of my people*, and mine elect shall *long enjoy* the work of their hands. They shall not labour in vain, nor bring forth for trouble; for they are the seed of the blessed of the Lord, and their offspring with them." "The seed shall be prosperous; the vine shall give her fruit, and the ground shall give her increase, and the heavens shall give their dew." "The evil beasts shall cease out of the land: and they shall sit every man under his vine, and under his fig-tree; and none shall make him afraid." "For wars shall cease to the ends of the world; and the knowledge of the Lord shall cover the earth, as the waters cover the sea."[1] Diseases will be, in a great measure, banished from the world, and the life of man extended far beyond its present duration—agriculture will be brought to perfection—commodious habitations erected for the comfortable accommodation of all ranks—cities built on elegant and spacious plans, adapted to health, ornament, and pleasure, divested of all the filth, and darkness and gloom, and narrow lanes, which now disgrace the abodes of men—roads

1 Psalm lxvii, 6; Isaiah, xxx, 23, 24; xxxiii, 24; lxv, 21-23; Zech. viii, 12; Micah, iv, 4, etc.

will be constructed on improved principles, with comfortable means of retreat for shelter and accommodation at all seasons; and conveyances invented for the ease, and safety, and rapid conveyance of persons and property from one place to another Either the climates of the earth will be meliorated by the universal cultivation of the soil, so that storms and tempests, thunders and lightnings, shall no longer produce their present ravages; or chemical and mechanical contrivances will be invented to ward off their destructive effects. The landscape of the earth will be adorned with vegetable and architectural beauty; and, instead of horse-racing, demoralizing plays, routs and masquerades, boxing and bull-fights—artificial displays of scenery will be exhibited, more congenial to the dignity of rational, renovated, and immortal minds. For "the knowledge of the Lord," and the "beauties of holiness," will pervade men of all ranks and ages, "from the least even to the greatest."[1]

Now, as we have no reason to expect any *miraculous interference*, we must regard the past and the future useful inventions of philosophy and mechanics as having a bearing on this glorious period, and a tendency to promote the improvement and the felicity of those who shall live during this era of Messiah's reign. If diseases are to be generally abolished, it will be owing to the researches of the scientific physician in discovering certain antidotes against every disorder, and to the practice of temperance, meekness, equanimity, and every other mean of preserving the vigour of the animal frame. For vicious passions and pursuits are the source of numerous disorders which, along with the anxieties, per-

[1] The various circumstances above stated, may be considered as the *natural results* of a state of society on which the light of science and of revelation has diffused its full influence, and where the active powers of the human mind are invariably directed by the pure principles and precepts of Christianity. That the duration of human life, at the era referred to, will be extended beyond its present boundary, appears to be intimated in some of the passages above quoted, particularly the following:—"*As the days of a tree shall be the days of my people*, and mine elect shall *long* enjoy the work of their hands." And if the life of man will be thus protracted to an indefinite period, it will follow, that those *diseases* which now prey upon the human frame, and cut short its vital action, will be in a great measure extirpated. Both these effects may be viewed (without supposing any miraculous interference) as the natural consequence of that happiness and equanimity which will flow from the practice of Christian virtues, from the enlargement of our knowledge of the principles of nature and from the physical enjoyments which such a state of society will furnish.

plexities, and remorse which accompany them, gradually prey upon the human frame, and cut short the period of human existence—while the regular exercise of faith, love, hope, joy, and other Christian graces, have an evident tendency to promote both health and longevity. If the earth is to produce its treasures in abundance, and with little labour, it will be owing in part to the improvement of agricultural science, and of the instruments by which its operations are conducted. If the lightnings of heaven shall no longer prove destructive to man and to the labours of his hands, it will be effected either by machinery for drawing off the electricity of a stormy cloud, or by the invention of *thunder-guards,* which shall afford a complete protection from its ravages. In these, and numerous other instances, the inventions of men, under the guidance of the Spirit of Wisdom, will have a tendency to remove a great part of the *curse* which has so long hung over our sinful world. And since the inventions of human skill and ingenuity for the melioration of mankind, and for the swift conveyance of intelligence, have of late years been rapidly encreasing, *at the same time* when the Christian world is roused to encreased exertions in disseminating the Scriptures throughout all lands, when general knowledge is encreasingly diffused, and when the fabric of Superstition and Despotism is skaking to its foundations,—these combined and simultaneous movements seem plainly to indicate, that that auspicious era is fast hastening on, when "the glory of Jehovah shall be revealed, and all flesh shall see it together," when "righteousness and praise shall spring forth before all nations," and when "Holiness to the Lord" shall be inscribed on all the pursuits and implements and employments of men.

Lastly, if the remarks suggested above be well founded, we may conclude, that the mechanical and philosophical inventions of genius are worthy of the attentive consideration of the enlightened Christian, particularly in the relation they may have to the accomplishment of religious objects. He should contemplate the experiments of scientific men, not as a waste of time, or the mere gratification of an idle curiosity, but as embodying the germs of those improvements by which civilization, domestic comfort, knowledge, and moral principle may be diffused among the nations. To view such objects with apathy and indifference, as beneath the regard of a religious character, argues a weak and limited understanding, and a contracted view of the grand operations of a superintending Providence.

CHAPTER IV.

SCRIPTURAL DOCTRINES AND FACTS ILLUSTRATED FROM THE SYSTEM OF NATURE.[1]

WITHOUT spending time in any introductory observations on this subject, it may be remarked in general,

I.—THAT SCIENTIFIC KNOWLEDGE, OR AN ACQUAINTANCE WITH THE SYSTEM OF NATURE, MAY FREQUENTLY SERVE AS A GUIDE TO THE TRUE INTERPRETATION OF SCRIPTURE.

It may be laid down as a universal principle, that there can be no real discrepancy between a just interpretation of Scripture and the facts of physical science; and on this principle the following canon is founded, which may be considered as an infallible rule for Scripture interpretation, namely,—*That no interpretation of Scripture ought to be admitted which is inconsistent with any well authenticated facts in the material world.* By *well authenticated facts* I do not mean the theories of philosophers, or the deductions they may have drawn from them, nor the confident assertions or plausible reasonings of scientific men in support of any prevailing system of natural science; but those facts which are universally admitted, and the reality of which every scientific enquirer has it in his power to ascertain; such as, that the earth is not an extended plane, but a round or globular body, and that the rays of the sun, when converged to a focus by a large convex glass, will set fire to combustible substances. Such facts, when ascertained, ought to be considered as a revelation from God, as well as the

[1] Under this head it was originally intended to embrace an elucidation of a considerable variety of the facts recorded in the Sacred History, and of the allusions of the inspired writers to the system of Nature; but as the volume has already swelled beyond the limits proposed, I am reluctantly compelled to confine myself to the illustration of only two or three topics.

declarations of his word. For they make known to us a portion of his character, of his plans, and of his operations.—This rule may be otherwise expressed as follows:—*Where a passage of Scripture is of doubtful meaning, or capable of different interpretations, that interpretation ought to be preferred which will best agree with the established discoveries of science.* For, since the Author of revelation and the Author of universal nature is one and the same Infinite Being, there must exist a complete harmony between the revelations of his Word and the facts or relations which are observed in the material universe. To suppose the contrary would be to suppose the Almighty capable of inconsistency; a supposition which would go far to shake our confidence in the theology of Nature as well as of Revelation. If, in any one instance, a Record claiming to be a revelation from heaven, were found to contradict a well-known fact in the material world; if, for example, it asserted, in express terms, to be literally understood, that the earth is a *quiescent* body in the centre of the universe, or that the moon is no larger than a mountain—it would be a fair conclusion, either that the revelation is not Divine—or that the passages embodying such assertions are interpolations—or that science, in reference to these points, has not yet arrived at the truth. The example, we are aware, is inapplicable to the Christian revelation, which rests securely on its own basis, and to which science is gradually approximating, as it advances in the amplitude of its views, and the correctness of its deductions; but it shows us how necessary it is, in interpreting the *Word* of God, to keep our eye fixed upon his *works;* for we may rest assured, that *truth* in the one will always correspond with *fact* in the other.

To illustrate the rule now laid down, an example or two may be stated.—If it be a fact that geological truth has ascertained that the materials of the strata of the earth are of a more ancient date than the Mosaic account of the commencement of the present race of men—the passages in the first chapter of Genesis, and other parts of scripture, which refer to the origin of our world, must be explained as conveying the idea that the earth was then merely *arranged* into its present form and order, out of the materials which *previously existed,* and which had been created by the Almighty at a prior period in duration. For Moses nowhere asserts that the materials of our globe were created or brought into existence out of nothing, at the time to which his history refers; but

insinuates the contrary. "For the earth," says he, prior to its present constitution, "*was* without form and void," etc.—Again, if it be a fact that the universe is indefinitely extended, that, of many millions of vast globes which diversify the voids of space, only two or three have any immediate connection with the earth —then it will appear most reasonable to conclude, that those expressions in the Mosaic history of the creation, which refer to the creation of the fixed stars, are not to be understood as referring to the *time* when they were brought into existence, as if they had been created about the same time with our earth; but as simply declaring the fact that, at what period soever in duration they were created, *they derived their existence from God.* That they did not all commence their existence at that period, is demonstrable from the fact that, within the space of two thousand years past, and even within the space of the last two centuries, new stars have appeared in the heavens, which previously did not exist in the concave of the firmament; which, consequently, have been created since the Mosaic period; or, at least, had undergone a change analogous to that which took place on our globe when it emerged from a chaotic state, to the form and order in which we now behold it. Consequently the phrase, "God rested from all his works," must be understood, not absolutely, or in reference to the whole system of nature, but merely in relation to our world; and as importing that the Creator then ceased to form any new species of beings *on the terraqueous Globe.*—The same canon will direct us in the interpretation of those passages which refer to the last judgment, and the destruction of the present constitution of our globe. When, in reference to these events, it is said that "the stars shall fall from heaven," that "the powers of heaven shall be shaken," and that "the earth and the heavens shall flee away," our knowledge of the system of nature leads us to conclude, either that such expressions are merely metaphorical, or that they describe only the *appearance*, not the *reality* of things. For it is impossible that the stars can ever fall to the earth, since each of them is vastly superior to our globe, and could never be attracted to its surface without unhinging the laws and the fabric of universal nature. The *appearance*, however, of the "heaven fleeing away," would be produced should the earth's diurnal rotation, at that period, be suddenly stopped, as will most probably happen; in which case, all

nature, in this sublunary system, would be thrown into confusion, and the heavens, with all their host, would appear to flee away.

Now, the scientific student of Scripture alone can judiciously apply the canon to which I have adverted; he alone can appreciate its utility in the interpretation of the sacred oracles; for he knows the facts which the philosopher and the astronomer have ascertained to exist in the system of nature; from the want of which information many divines, whose comments on Scripture have in other respects been judicious, have displayed their ignorance, and fallen into egregious blunders, when attempting to explain the first chapters of Genesis, and several parts of the book of Job—which have tended to bring discredit on the oracles of heaven.

II.—THE SYSTEM OF NATURE CONFIRMS AND ILLUSTRATES THE SCRIPTURAL DOCTRINE OF THE DEPRAVITY OF MAN.

In the preceding parts of this work, I have stated several striking instances of Divine benevolence, which appear in the construction of the organs of the animal system, in the constitution of the earth, the waters, and the atmosphere, and in the *variety* of beauties and sublimities which adorn the face of nature; all which proclaim, in language which can scarcely be mistaken, that the Creator has a special regard to the happiness of his creatures. Yet the Scriptures uniformly declare, that man has fallen from his primeval state of innocence, and has violated the laws of his Maker; that "his heart is deceitful above all things, and desperately wicked;" and that "destruction and misery are in his ways." Observation and experience also demonstrate, that a moral disease pervades the whole human family, from the most savage to the most civilized tribes of mankind; which has displayed its virulence in those wars and devastations which have, in all ages, convulsed the world; and which daily displays itself in those acts of injustice, fraud, oppression, malice, tyranny, and cruelty, which are perpetrated in every country, and among all the ranks even of civilized life. That a world inhabited by moral agents of this description would display, in its physical constitution, certain indications of its Creator's displeasure, is what we should naturally expect, from a consideration of those attributes of his nature with which we are acquainted. Accordingly we find, that, amidst all the evidences

of benevolence which our globe exhibits, there are not wanting certain displays of "the wrath of Heaven against the ungodliness and unrighteousness of men," in order to arouse them to a sense of their guilt, and to inspire them with reverence and awe of that Being whom they have offended. The following facts, among many others, may be considered as corroborating this position.

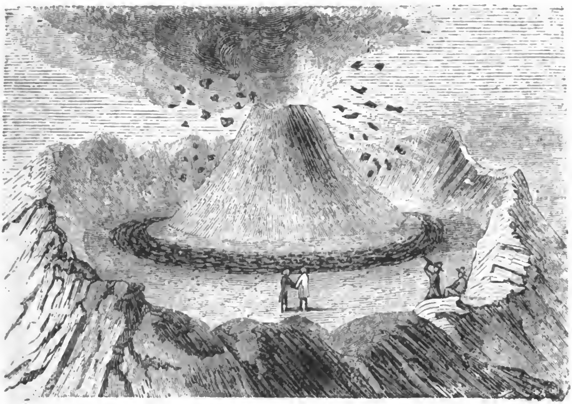
In the first place, *The present state of the interior strata of the earth* may be considered as a presumptive evidence, that a moral revolution has taken place since man was placed upon the globe. When we penetrate into the interior recesses of the earth, we find its different strata bent in the most irregular forms; sometimes lying horizontally, sometimes projecting upwards, and sometimes downwards, and thrown into confusion; as if some dreadful concussion had spread its ravages through every part of the solid crust of our globe. This is visible in every region of the earth. Wherever the miner penetrates among his subterraneous recesses, wherever the fissures and caverns of the earth are explored, and wherever the mountains lay bare their rugged cliffs, the marks of ruin, convulsion, and disorder, meet the eye of the beholder. Evidences of these facts are to be found in the records of all intelligent travellers and geologists who have visited Alpine districts, or explored the subterraneous regions of the earth; of which I have already stated a few instances in the article *Geology*.—These facts seem evidently to indicate, that the earth is not now in the same state in which it originally proceeded from the hand of its Creator; for such a scene of disruption and derangement appears incompatible with that order, harmony, and beauty, which are apparent in the other departments of nature. We dare not assert, that such terrible convulsions took place by chance, or independent of the will of the Creator; nor dare we insinuate, that they were the effects of a random display of Almighty power; and, therefore, we are necessarily led to infer, that a *moral* cause, connected with the conduct of the rational inhabitants of the globe, must have existed, to warrant so awful an interposition of Divine power; for the fate of the animated beings which then peopled the earth, was involved in the consequences which must have attended this terrible catastrophe. The volume of Revelation on this point concurs with the deductions of reason, and assigns a cause adequate to warrant the production of such an extraordinary effect. "The wickedness of man was GREAT upon the earth; the earth was FILLED WITH VIO-

LENCE; every purpose and desire of man's heart was ONLY EVIL CONTINUALLY." Man had frustrated the end of his existence; the earth was turned into a habitation of demons; the long period to which his life was protracted, only served to harden him in his wickedness, and to enable him to carry his diabolical schemes to their utmost extent, till the social state of the human race became a scene of unmixed depravity and misery. And the physical effects of the punishment of this universal defection from God are presented to our view in every land, and will remain to all ages, as a visible memorial that man has rebelled against the authority of his maker.[1]

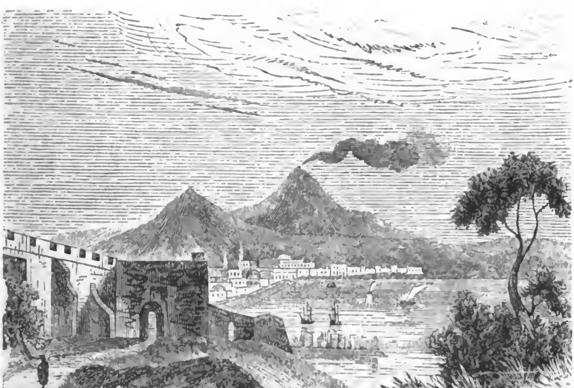
2. *The existence of volcanoes and the terrible ravages they produce*, bear testimony to the state of man as a depraved intelligence. A volcano is a mountain, generally of an immense size, from whose summit issue fire, smoke, sulphur, and torrents of melted lava.[2] Previous to an eruption, the smoke, which is continually ascending from the *crater*, or opening in the top, encreases and shoots up to an immense height; forked lightning issues from the ascending column; showers of ashes are thrown out to the distance of forty or fifty miles; volleys of red-hot stones are discharged to a great height in the air; the sky appears thick and dark; the luminaries of heaven disappear; and these terrible forebodings are accompanied with thunder, lightning, frequent concussions of the earth, and dreadful subterraneous bellowings. When these alarming appearances have continued sometimes four or five months, the lava begins to make its appearance, either boiling over the top, or forcing its way through the side of the mountain. This fiery deluge of melted minerals rolls down the declivity of the mountain,

[1] It is not meant here to insinuate that *all* the dislocations and irregularities found in the strata of the earth are to be attributed to the action of the deluge; but it can scarcely be called in question, that certain traces of the effects of this catastrophe are to be found in most countries. The simple fact, recorded in Revelation, that "the fountains of the great deep were broken up, and the flood-gates of the heavens opened"—that "the storm of rain continued upon the earth forty days and forty nights," and that the earth was covered with water for nearly the space of a whole year—could not but produce a very sensible and extensive effect upon the solid parts of the globe, though it may be difficult in some instances to distinguish some of the effects produced by Noah's flood from those which were the result of previous catastrophes. At any rate, the sacred historian is explicit in declaring it was "because the wickedness of man was great," that "a flood of waters was brought upon the earth."

[2] See page 581.



CRATER OF VESUVIUS DURING AN ERUPTION.



VESUVIUS NOT IN A STATE OF ERUPTION.

forming a dismal flaming stream, sometimes fourteen miles long, six miles broad, and 200 feet deep. In its course it destroys orchards, vineyards, corn fields, and villages; and sometimes cities, containing twenty thousand inhabitants, have been swallowed up and consumed. Several other phenomena, of awful sublimity, sometimes accompany these eruptions. In the eruption of Vesuvius, in 1794, a shock of an earthquake was felt; and at the same instant a fountain of bright fire, attended with the blackest smoke and a loud report, was seen to issue, and to rise to a great height from the cone of the mountain; and was soon succeeded by fifteen other fiery fountains, all in a direct line, extending for a mile and a half downwards. This fiery scene was accompanied by the loudest thunder, the incessant reports of which, like those of a numerous heavy artillery, were attended by a continued hollow murmur, similar to that of the roaring of the ocean during a violent storm. The houses in Naples, at seven miles distance, were for several hours in a constant tremor; the bells ringing, and doors and windows incessantly rattling and shaking. The murmur of the prayers and lamentations of a numerous population added to the horrors of the scene. All travellers who have witnessed these eruptions seem to be at a loss to find words sufficiently emphatic to express the terrors of the scene. "One cannot form a juster idea," says Bishop Berkley, "of the *noise* emitted by the mountain, than by imagining a mixed sound made up of the raging of a tempest, the murmur of a troubled sea, and the roaring of thunder and artillery, confused altogether. Though we heard this at the distance of twelve miles yet it was *very terrible*." In 1744, the flames of Cotopaxi, in South America, rose 3000 feet above the brink of the crater, and its roarings were heard at the distance of *six hundred miles*. "At the port of Guayaquil, 150 miles distant from the crater," says Humboldt, "we heard dáy and night the noise of this volcano, like continued discharges of a battery, and we distinguished these tremendous sounds even on the Pacific ocean."

The following figures (43, 44) represent the interior of the crater of Mount Vesuvius, and its appearance during an eruption; as also a view of the mountain in its ordinary state, when throwing out a volume of smoke, and a portion of the city of Naples, which is about 6 miles distant from the mountain.

The most terrific and extraordinary volcano yet known is that

of Kirauea, discovered in Hawaii, one of the Sandwich islands. When the crater of this volcano first bursts upon the sight, there is an appearance presented of an immense plain below, 15 or 16 miles in circumference, and from 200 to 400 feet below its original level, covered with hillocks of lava, and vast floods of burning matter in a state of terrific ebullition, moving to and fro its fiery surge and flaming billows. Mr. Ellis, who beheld this volcano, states that, around the edge, or from the surface of the burning lake, there arose no fewer than fifty-one conical islands of varied form and size, containing as many craters. Twenty-two were constantly emitting columns of grey smoke or pyramids of brilliant flame, and several of these at the same time vomited from their ignited mouths streams of lava which rolled in blazing torrents down their black indented sides into the boiling mass below. The roar and noise emitted from these several craters resemble the sounds of a mighty steam-engine—*a whole lake of fire* appearing in the distance—billow after billow tossing its monstrous bosom in the air, and throwing forth its fiery spray to the height of 40 or 50 feet—forming a scene most awfully grand and terrific—flames bursting forth from the largest cone, red-hot stones, cinders, and ashes propelled to a mighty height with immense violence, and appalling floods of lava boiling down the sides over the surrounding scoriæ. Mr. Stewart and a party from the Blonde frigate visited this volcano in 1825. The following is only a very small part of his description:—"At night, splendid illuminations were lighted up; the volcano began roaring and labouring with redoubled activity. The confusion of the noises was prodigiously great—rolling from one end of the crater to the other, sometimes seeming to be immediately under us, when a sensible tremor of the ground took place, and then again rushing to the further end with incalculable velocity. The whole air was filled with the tumult, and soon after flames burst from a large cone near which we had been in the morning. Red-hot stones, cinders, and ashes were also propelled to a great height with immense violence, and shortly after the molten lava came boiling up and flowed down the sides of the cone and over the surrounding scoriæ, in two beautiful streams, glittering with indescribable brilliance. At the same time, a whole lake of fire opened in a more distant part; this could not have been less than *two miles* in circumference; and its action was more horribly sublime than anything I ever imagined

to exist, even in the ideal visions of unearthly things." This fiery volcano of Kirauea, the largest of which we have any record, dwindles into insignificance, when we think of the probable subterranean fires immediately beneath the whole of these and other South Sea islands. The whole of Hawaii (Owhyhee), covering a space of 4000 square miles, is a complete mass of lava or other volcanic matter in various stages of decomposition. Perforated with innumerable apertures in the shape of craters, it forms a hollow cone over one vast furnace, situated in the heart of a stupendous submarine mountain, rising from the bottom of the sea. When we contemplate such awful and overwhelming phenomena, the workmanship of Him who laid the foundations of the earth, and who superintends the operations of all its elementary principles, we have reason to exclaim, "Let the nations say unto God, How terrible art thou in thy works! Let all the earth fear Jehovah; let all the inhabitants of the world stand in awe of Him!"

The *ravages* produced by volcanoes are in proportion to the terror they inspire. In the eruption of Etna in 1669, the stream of lava destroyed, in forty days, the habitations of 27,000 persons; and, of 20,000 inhabitants of the city of Catania, only 3000 escaped. In the year 79, the celebrated cities of Pompeii and Herculaneum were completely overwhelmed and buried under ground by an eruption of Vesuvius, and the spots on which they stood remained unknown for 1600 years. Since that period about forty eruptions have taken place, some of them producing the most dreadful ravages. But the volcanoes of Asia and America are still more terrible and destructive than those of Europe. The volcanic mountain Pichincha, near Quito, caused, on one occasion, the destruction of 35,000 inhabitants. In the year 1772, an eruption of a mountain in the island of Java, destroyed forty villages, and several thousands of the inhabitants; and in October, 1822, eighty-eight hamlets and above 2000 persons were destroyed in the same island, by a sudden eruption from a new volcano. The eruption from Tomboro, in the island of Sumbawa, in 1815, was so dreadful that all the Moluccas, Java, Sumatra, and Borneo, to the distance of a thousand miles from the mountain, felt tremulous emotions, and heard the report of explosions. In Java, at the distance of 340 miles, the clouds of ashes from the volcano produced utter darkness.

Volcanoes are more numerous than is generally imagined.

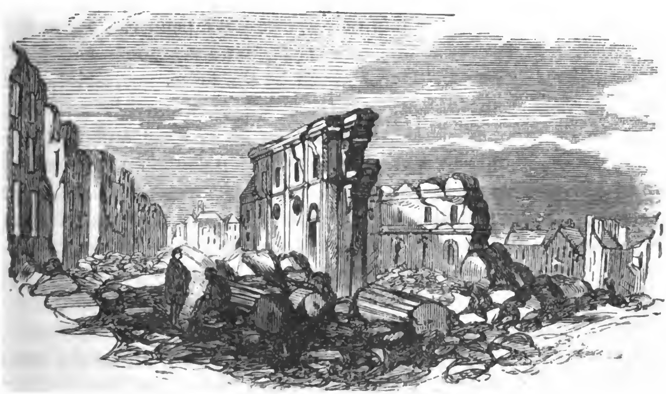
They are to be found in every quarter of the world, from the icy shores of Kamtschatka to the mountains of Patagonia. Humboldt enumerates forty volcanoes constantly burning between Cotopaxi and the Pacific ocean; twenty have been observed in the chain of mountains that stretches along Kamtschatka; and many of them are to be seen in the Philippines, the Moluccas, the Cape de Verd, the Sandwich, the Ladrone, and other islands in the Indian and Pacific ocean. It is stated in vol. 6th of *Sup. to Ency. Brit.* that about 205 volcanoes are known, including only those which have been active within a period to which history or tradition reaches. Europe contains 14; and of the whole number, it is computed that 107 are in islands and 98 on the great continents.

Can we then suppose that so many engines of terror and destruction, dispersed over every quarter of the globe, are consistent with the conduct of a benevolent Creator towards an *innocent* race of men? If so, we must admit either that the Creator had it not in his power, when arranging our terrestrial system, to prevent the occasional action of these dreadful ravagers; or, that he is indifferent to the happiness of his innocent offspring. The former admission is inconsistent with the idea of his Omnipotence, and the latter with the idea of his universal Benevolence. It is not, therefore, enthusiasm, but the fairest deduction of reason, to conclude, that they are indications of God's displeasure against a race of transgressors who have apostatized from his laws.

3. The same reasoning will apply to the ravages produced by *Earthquakes*. Next to volcanoes, earthquakes are the most terrific phenomena of nature, and are even far more destructive to man, and to the labours of his hands. An earthquake, which consists in a sudden motion of the earth, is generally preceded by a rumbling sound, sometimes like that of a number of carriages driving furiously along the pavement of a street, sometimes like the rushing noise of a mighty wind, and sometimes like the explosions of artillery. Their effect on the surface of the earth is various. Sometimes it is instantaneously heaved up in a perpendicular direction, and sometimes it assumes a kind of rolling motion, from side to side.—The ravages which earthquakes have produced are terrible beyond description; and are accomplished almost in a moment. In 1692, the city of Port-Royal, in Jamaica, was destroyed by an earthquake, in the space of two minutes, and the houses sunk into a gulf forty fathoms deep. In 1693, an earth

quake happened in Sicily, which either destroyed, or greatly damaged fifty-four cities and an incredible number of villages. The city of Catania was utterly overthrown; the sea all of a sudden began to roar; Mount Etna to send forth immense spires of flame; and, immediately a shock ensued, as if all the artillery in the world had been discharged. The birds flew about astonished; the sun was darkened; the beasts ran howling from the hills; a dark cloud of dust covered the air; and though the shock did not last three minutes, yet nineteen thousand of the inhabitants of the city perished in the ruins. This shock extended to a circumference of 7000 miles.

Earthquakes have been producing their ravages in various parts of the world, and in every age, and are still continuing their destructive effects. Pliny informs us, that twelve cities in Asia Minor were swallowed up in one night. In the year 115, the city of Antioch, and a great part of the adjacent country, were buried by an earthquake. About 300 years after, it was again destroyed along with 40,000 inhabitants; and, after an interval of only 60 years, it was a third time overturned, with the loss of not less than 60,000 souls. In 1755, Lisbon was destroyed by an earthquake,



LISBON DESTROYED BY AN EARTHQUAKE.

and it buried under its ruins above 50,000 inhabitants. The effects of this terrible earthquake were felt over the greater part of Europe and Africa, and even in the midst of the Atlantic ocean; and are

calculated to have extended over a space of not less than four millions of square miles. In August 1822, two thirds of the city of Aleppo, which contained 40,000 houses, and 200,000 inhabitants, were destroyed by an earthquake, and nearly 30,000 inhabitants were buried under the ruins.—On the 7th May, 1842, at 5 o'clock in the evening, the town of Cape Haytien in the island of St. Domingo, was totally destroyed by an earthquake, and ten thousand of the inhabitants—forming two-thirds of the population —perished in the catastrophe. The towns of St. Nicholas and Port Paix, were also tumbled into ruins, and most if not all towns on the north side of the island, in some of which multitudes of the inhabitants were destroyed, amounting in all to about 20,000 human beings who perished in that tremendous concussion. Its effects were traced from W. Longitude 56° in the northern part of the tropics, to W. Longitude 91°, comprehending an extent, from east to west, of 35°, passing along Cuba, Louisiana, and part of the United States. As late as last year (1855) the town of Broussa, in Turkey, was almost destroyed by a succession of earthquakes; and now, while we write, (March 1856), we hear of a terrible visitation of earthquakes in the island of Japan, by which 30,000 human beings have lost their lives.

To suppose that the human beings who have been victims to the ravages of earthquakes and volcanoes, "were sinners above all those who dwelt around them," would be the height of impiety and presumption. But the fact, that thousands of rational beings have been swept from existence, in a manner so horrible and tremendous, seems plainly to indicate, that they belonged to a race of apostate intelligencies, who had violated the commands of their Creator. Such visitations are quite accordant to the idea of man being in the condition of a transgressor; but, if he were an *innocent* creature, they would be altogether unaccountable, as happening under the government of a Being of unbounded benevolence.

4. The phenomena of *thunder-storms*, *tempests*, and *hurricanes*, and the ravages they produce, are also presumptive proofs that man is a depraved intelligence. In that season of the year when Nature is arrayed in her most beautiful attire, and the whole terrestrial landscape tends to inspire the mind with cheerfulness—suddenly a sable cloud emerges from the horizon—the sky assumes a baleful aspect—a dismal gloom envelopes the face of Nature—the lightnings flash from one end of the horizon to another—the thunders

roll with awful majesty along the verge of heaven, till at length they burst overhead in tremendous explosions. The sturdy oak is shattered and despoiled of its foliage; rocks are rent into shivers; and the grazing herds are struck into a lifeless group. Even *man* is not exempted from danger in the midst of this appalling scene. For hundreds in every age have fallen victims either to the direct stroke of the lightning, or to the concussions and conflagrations with which it has been attended. In tropical countries, the phenomena of thunder-storms are more dreadful and appalling than in our temperate climate. The thunder frequently continues for days and weeks in almost one incessant roar; the rains are poured down in torrents; and the flashes of lightning follow each other in so rapid a succession that the whole atmosphere and the surrounding hills seem to be in a blaze. In some instances, the most dreadful effects have been produced by the bursting of an electrical cloud. In 1772, a bright cloud was observed at midnight to cover a mountain in the island of Java; it emitted globes of fire so luminous that the night became as clear as day. Its effects were astonishing. Every thing was destroyed for seven leagues round; houses were demolished; plantations buried in the earth; and 2140 people lost their lives, besides 1500 head of cattle, and a vast number of horses and other animals.[1]

Is it not reasonable, then, to conclude, that such awful phenomena as storms, volcanoes, and earthquakes are so many occasional indications of the frown of an offended Creator upon a race of transgressors, in order to arouse them to a sense of their apostacy from the God of heaven? We cannot conceive that such physical operations, accompanied by so many terrific and destructive effects, are at all compatible with the idea, that man is at present in a *paradisaical* state, and possessed of that *moral* purity in which he was created. Such appaling displays of Almighty power are in complete unison with the idea, that man is a transgressor, and that the present dispensations of God are a mixture of mercy and of judgment; but if he belong to an innocent race of moral intelligences, they appear quite anomalous, and are altogether inexplicable, on the supposition, that a Being of infinite benevolence and rectitude directs the operations of the physical and moral world; more especially when we consider the admirable care which is displayed in the construction of animal bodies, in order to pre-

[1] Encyc. Brit. Art. *Cloud.*

vent pain, and to produce pleasurable sensations. When man was first brought into existence, his thoughts and affections, we must suppose, were in unison with the will of his Creator; his mind was serene and unruffled; and consequently, no foreboding apprehensions of danger would, in such a state, take possession of his breast. But after he had swerved from the path of primeval rectitude, and especially after the Deluge had swept away the inhabitants of the Antediluvian world, the constitution of the earth and the atmosphere seems to have undergone a mighty change, corresponding to the degraded state into which he had falllen; so that those very elements which may have formerly ministered to his enjoyment—by being formed into different combinations—now conspire to produce terror and destruction.

The same important conclusion might have been deduced, from a consideration of the immense deserts of marshes and barren sands which are dispersed over the globe—the vast and frightful regions of ice around the poles—the position of the mineral strata, and the vast disproportion which the extent of the dry land bears to the expanse of the ocean,—all which circumstances, and many others, in conjunction with the facts above stated, conspire to show, that man no longer stands in the rank of a pure intelligence; and that his habitation corresponds, in some degree, to his state of moral degradation. By overlooking this consideration, St. Pierre and other Naturalists have found themselves much at a loss, when attempting to vindicate the wisdom and equity of Providence in the physical disorders which exist in the present constitution of our globe. The circumstance, that man is a fallen creature, appears the only clue to guide us in unravelling the mysteries of Providence, and to enable us to perceive the *harmony* and *consistency* of the Divine operations in the system of nature; and no other consideration will fully account for the disorders which exist in the present economy of our world.

But it is a most consoling consideration, that, amidst all the physical evils which abound, the benevolence and mercy of God are admirably blended with the indications of his displeasure. Thunder-storms and tempests contribute to the purification of the atmosphere; and volcanoes are converted into funnels for vomiting up those fiery materials which produce earthquakes, and which might otherwise swallow up whole provinces in one mighty gulf. In the *ordinary course* of things, such phenomena are more terrific

than destructive; and are calculated rather to rouse an unthinking world to consideration, than to prove the instruments of human destruction. Compared with the miseries which men have voluntarily inflicted on one another, the destructive effects of the elenents of nature dwindle into mere temporary and trifling accidents. We have reason to believe, that a much greater destruction of human beings has been produced by two or three of the late battles in modern Europe, such as those of Waterloo, Borodina, and Smolensko, than has been produced by all the electrical storms, earthquakes, and volcanic eruptions, which have raged for the space of several hundreds of years. It has been calculated, that, during the Russian Campaign of 1812, including men, women, and children, belonging to the French and Russians, there were not less than five hundred thousand human victims sacrificed to the demon of war. It is probable, that the destruction produced among the human race, by the convulsions of nature, since the commencement of time, (the deluge only excepted,) does not amount to above four or five millions of lives; but were we to take into account the destruction of human life produced by ambition, tyranny, oppression, superstition, wars, devastations, murders, and horrid cruelties, in every period of the world, it would, doubtless, amount to several thousands of millions. So that, amidst the most terrible displays of the displeasure of God against the sins of men, *mercy* is mingled with judgment; and while man is the greatest enemy and destroyer of his own species, benevolence is the *prominent* feature of all the arrangements of the Deity in the physical world. For although he is great in power he is slow to anger, and "his tender mercies are over all his works." The evils which flow from the operation of the elements of nature ought not to be considered as the inflictions of avenging justice, but as the kind admonitions of a benevolent Father, who willeth not that any should perish, but that all should come to repentance—and who has displayed his love to the human race in such a wonderful manner that "he gave his only-begotten Son, that whosoever believeth on him might not perish but have everlasting life."[1]

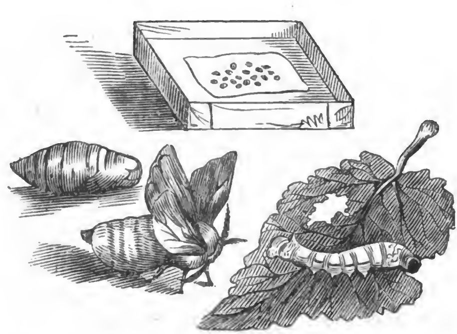
1 The facts stated in this section are expressed, for the most part, in the author's own words, for the sake of compression.—His authorities are, Goldsmith's Natural History, Humboldt's Travels, Brydone's Tour, Sir W. Hamilton's Observations, Raffle's History of Java, Encyc. Brit. Art. *Etna, Volcano, Earthquake, Antioch, Cloud.*—Ellis's Polynesian Researches, etc.

III.—THE DISCOVERIES WHICH HAVE BEEN MADE IN THE SYSTEM OF NATURE ILLUSTRATE THE DOCTRINE OF THE RESURRECTION OF THE DEAD.

The doctrine of a Resurrection from the dead, at first view, appears to involve in it a variety of difficulties and apparent contradictions. That a complex organical machine, as the human body is, consisting of thousands of diversified parts for the performance of its functions, after it has been reduced to atoms, and those atoms dispersed to "the four winds of heaven"—should be again reared up with the same materials, in a new and more glorious form,—is an idea which seems to baffle the human comprehension; and, in all probability, would never have entered the mind of man, had it not been communicated by Divine Revelation. Accordingly we find, that the philosophers of antiquity, though many of them believed in the doctrine of a future state, never once dreamed that the bodies of men, after they had been committed to the dust, would ever again be reanimated; and hence, when the apostle Paul proposed this doctrine to the Athenian philosophers, they scouted the idea, as if it had been the revery of a madman. And, indeed, without a strong conviction, and a lively impression, of the infinite power and intelligence of God, the mind cannot rely with unshaken confidence on the declaration of a future fact so widely different from all the obvious phenomena of nature, and from every thing that lies within the range of human experience. "If a man die," says Job, "shall he live again? There is hope of a tree, if it be cut down, that it will sprout again, and bring forth boughs like a plant. But man dieth and wasteth away; yea, man giveth up the ghost, and where is he?" When the mind, however, is frequently exercised in contemplations on the stupendous works of the Almighty, it must feel an impressive conviction, that "nothing can be too hard for Jehovah." When we endeavour to draw aside the vail which conceals many of the scenes of nature from the vulgar eye, we perceive a variety of operations and analogies, which tend to assist us in forming a conception, not only of the *possibility* of a resurrection, but also of the *manner* in which it may probably be effected, when the power of Omnipotence is interposed.

The transformation of insects affords us a beautiful illustration

of this subject. All the butterflies which we see fluttering about in the summer months were originally caterpillars. Before they arrive at the highest stage of their existence, they pass through four different transformations. The first state of a butterfly is



EGGS, GRUB, BUTTERFLY, AND CATERPILLAR.

that of an *egg;* it next assumes the form of a loathsome crawling *worm;* after remaining some time in this state, it throws off its caterpillar skin, languishes, refuses to eat, ceases to move, and is shut up, as it were, in a tomb. In this state, the animal is termed a *chrysalis:* it is covered with a thin crust or shell, and remains, sometimes for six or eight months, without motion, and apparently without life. After remaining its allotted time in this torpid condition, it begins to acquire new life and vigour; it bursts its imprisonment, and comes forth a butterfly, with wings tinged with the most beautiful colours. It mounts the air, it ranges from flower to flower, and seems to rejoice in its new and splendid existence. How very different does it appear in this state, from what it did in the preceding stages of its existence! How unlikely did it seem, that a rough, hairy, *crawling* worm, which lay for such a length of time, in a death-like torpor, and enshrouded in a tomb, should be reanimated, as it were, and changed into so beautiful a form, and endued with such powers of rapid motion! Perhaps the change to be effected on the bodies of men, at the general resurrection, may not be greater, nor more wonderful in its nature, than are the changes which take place from the first to the last

stage of a caterpillar's existence. In such transformations, then, we behold a lively representation of the death and resurrection of a righteous man. "A little while he shall lie in the ground, as the seed lies in the bosom of the earth; but he shall be raised again, and shall never die any more."

There is another illustration, taken from a consideration of the chemical changes of matter, which has a still more direct bearing on the doctrine of a resurrection. We know, that substances which are invisibly incorporated with air, water, and other fluids, and which seem to be destroyed, may be made to reappear in their original form by the application of certain chemical reagents. For example, put a small piece of solid camphor into a phial half filled with alcohol or spirit of wine—in a short time the camphor will be dissolved in the fluid, and the spirit will be as transparent as at first. If water be now added, it will unite with the ardent spirit, and the camphor will be separated and fall to the bottom of the phial. In this way the camphor may be nearly all recovered as at first; and by distillation, the alcohol may also be separated from the water, and exhibited in a separate state. I have already noticed that *carbon*, which forms an essential part of all animal and vegetable substances, is found to be not only indestructible by age, but in all its combinations, which are infinitely diversified, it still preserves its *identity*. In the state of carbonic acid, it exists in union with earths and stones in unbounded quantities; and, though buried for thousands of years beneath immense rocks, or in the centre of mountains, it is still carbonic acid: for no sooner is it disengaged from its dormitory, than it rises with all the life and vigour of recent formation, not in the least impaired by its torpid inactivity during the lapse of ages. The beams of the theatre at Herculaneum were converted into *charcoal* (which is one of the compounds of carbon), by the lava which overflowed that city during an eruption of mount Vesuvius; and, during the lapse of 1700 years, the charcoal has remained as entire as if it had been formed but yesterday, and it will probably continue so to the end of the world. In addition to these facts, it may be stated that provision has been made for the restoration of the fallen leaves of vegetables which rot upon the ground, and, to a careless observer, would appear to be lost for ever. It has been shown by experiment that, whenever the soil becomes charged with such matter, the oxygen of the atmosphere combines with it,

and converts it into carbonic acid gas. The consequence of which is, that *this very same carbon* is, in process of time, absorbed by a new race of vegetables, which it clothes with a new foliage, and which is itself destined to undergo similar putrefaction and renovation to the end of time.[1]

These facts, and others of a similar description, which might have been stated, demonstrate, that one of the constituent parts of animal bodies remains unalterably the same amidst all the revolutions of time, and all the changes and decompositions which take place in the system of nature; and, consequently, that though human bodies may remain in a state of putrefaction for ages, in the earth and in the waters, yet their component parts remain unchanged, and in readiness to enter into a new and more glorious combination, at the command of that INTELLIGENCE, to whom all the principles of nature, and all their diversified changes, are intimately known; and whose POWER is able to direct their combinations to the accomplishment of his purposes.—Though such considerations as these may have no weight on certain unreflecting minds, that never met with any difficulties in the economy either of Nature or of Redemption—yet the man of deep reflection, who has frequently had his mind distracted with the apparent improbability of the accomplishment of certain divine declarations, will joyfully embrace such facts in the economy of nature, as a *sensible support* to his faith in the promises of his God; and will resign his body to dust and putrefaction, in the firm hope of emerging from the tomb to a future and more glorious transformation.

IV.—THE DISCOVERIES OF SCIENCE TEND TO ILLUSTRATE THE DOCTRINE OF THE GENERAL CONFLAGRATION.

We are informed, in the Sacred Oracles, that a period is approaching, when "the elements shall melt with fervent heat, and the earth, and the works that are therein shall be burned up." Science has ascertained certain facts in the constitution of nature, which lead us to form some conception of the *manner* in which this awful catastrophe may probably be effected, and also of the ease with which it may be accomplished, when the destined period shall have arrived. It was formerly stated, that the atmosphere,

[1] Parke's Chemical Catechism, p. 266, and the additional Notes.

or the air we breathe, is a compound substance, composed of two very different and opposite principles, termed *oxygen* and *nitrogen*. The oxygen, which forms about a fifth part of the atmosphere, is now ascertained to be the principle of flame: a lighted taper, immersed in this gas, burns with a brilliancy too great for the eye to bear; and even a rod of iron or steel is made to blaze under its energy.

The modern infidel, like the scoffers of old, scouts the idea of the dissolution of the world, and of the restitution of the universe, because all things continue as they were from the beginning of the creation; not knowing the Scriptures, nor the Power of God; and not considering the principles and facts in the system of nature, which indicate the possibility of such an event. But, from the fact now stated, we may learn, how easily this effect may be accomplished, even in conformity with those laws which now operate in the constitution of our globe. For, should the Creator issue forth his Almighty fiat—"Let the nitrogen of the atmosphere be completely separated from the oxygen, and let the oxygen exert its native energies without control, wherever it extends;"—from what we know of its nature, we are warranted to conclude, that instantly a universal conflagration would commence throughout all the kingdoms of nature—not only wood, coals, sulphur, bitumen, and other combustible substances, but even the hardest rocks and stones, and all the metals, fossils, and minerals, and water itself, which is a compound of two inflammable substances, would blaze with a rapidity which would carry destruction through the whole expanse of the terraqueous globe, and change its present aspect into that of a new world:—at the same time, all the other laws of nature might still operate as they have hitherto done since the creation of the world.

Though I think it highly probable, I do not mean positively to assert, that this is the agent which the Almighty will certainly employ for accomplishing this terrible catastrophe, since Infinite Power is possessed of numerous resources for accomplishing its objects, which lie beyond the sphere of our knowledge and comprehension. But I have brought forward this fact, to show with what infinite ease this event may be accomplished, when Almighty Power is interposed. By means of the knowledge we have acquired of the constitution of the atmosphere, and by the aid of chemical apparatus, we can perform experiments on a *small scale*,

similar in kind, though infinitely inferior in degree, to the awful event under consideration. And, therefore, we can easily conceive that He who formed the expansive atmosphere which surrounds us, and who knows the native energy of its constituent principles, may, by a simple volition, make that invisible fluid, in a few moments, the cause of the destruction of the present constitution of our world, and, at the same time, the means of its subsequent renovation. For, as fire does not annihilate, but only changes the forms of matter, this globe on which we now tread, and which bears the marks of ruin and disruption in several parts of its structure, may come forth from the flames of a general conflagration, purified from all its physical evils, adorned with new beauties and sublimities, and rendered a fit habitation for pure intelligencies, either of our own species or of another order. For though "the heavens," or the atmosphere, "shall be dissolved, and the elements melt with fervent heat;" "yet," says the apostle Peter, "we, according to his promise, look for new heavens and a new earth, wherein dwelleth righteousness." Whether, after being thus renovated, it shall be allotted as the residence of the redeemed inhabitants of our world is beyond our province at present to determine. But if not, it will, in all probability, be allotted as the abode of other rational beings, who may be transported from other regions, to contemplate a new province of the Divine empire, or who may be immediately created for the purpose of taking possession of this renovated world. For we have reason to believe that the energies of Creating Power will be continually exerted, in replenishing the boundless universe, throughout all the ages of infinite duration; and that no substances, or worlds, which God has created, will ever be suffered to fall into annihilation—at least, that the original atoms of matter will never be destroyed, whatever new forms they may assume, and however varied the combinations into which they may enter.

The above are only a few examples out of many which were intended to be specified, of the illustrations which the system of nature affords of the doctrines and facts of Revelation, but the narrow limits of this work prevent further enlargement.

It was also intended to follow up the preceding discussions with particular illustrations of the following topics:—The views which science affords of the *incessant energies of Creating Power*—the changes and revolutions which appear to have happened, and which are still going on in the distant regions of the universe, *as tending*

to amplify our views of the grand and multifarious objects over which Divine Providence presides—the connection of science with a future state—the aids which the discoveries of science afford, in enabling us to form a conception of the scenes of future felicity—of the employments of the heavenly inhabitants, and of their perpetual advances in knowledge and happiness, and in their views of the perfections of Deity[1]—the *moral relations of intelligent beings* to their Creator, and to each other; and the *physical grounds or reasons* of those moral laws which the Deity has promulgated, for regulating the conduct, and for promoting the harmony and order of intelligent agents[2]—illustrations of the allusions of the Sacred writers to the system of the material world—the *simultaneous progress of science and religion*, considered as an evidence of the connexion of the one with the other—the *moral effects* of the study of science in connexion with religion—replies to objections and insinuations which have been thrown out against the idea of combining the discoveries of Science with the discoveries of Revelation, etc. But, as illustrations of these, and various other topics connected with them, would occupy several hundreds of pages, they must, in the mean time, be postponed.[3]

[1] Several of these subjects, along with many others, are fully illustrated in the author's volume, entitled, "The Philosophy of a Future State."

[2] These and a variety of kindred topics are illustrated at considerable length in my work entitled "The Philosophy of Religion; or, an Illustration of the Moral Laws of the Universe, on the Principles of Reason and of Divine Revelation"—in which an original and popular train of thought is prosecuted, and the different topics are enlivened with illustrative facts derived from the scenery of nature and the moral history of mankind.

[3] Several of the topics alluded to in this paragraph will be found more or less illustrated in the author's volumes, entitled "Celestial Scenery"—and "The Sidereal Heavens"—in which, "the incessant energies of Creating Power"—the changes and revolutions which have happened and are still going forward in the distant regions of the universe—the doctrine of a plurality of worlds—and many other kindred topics, are particularly elucidated.

CHAPTER V.

BENEFICIAL EFFECTS WHICH MIGHT RESULT TO CHRISTIAN SOCIETY, FROM CONNECTING THE DISCOVERIES OF SCIENCE WITH THE OBJECTS OF RELIGION.

I.—THE VARIETY OF TOPICS WHICH WOULD BE INTRODUCED INTO CHRISTIAN INSTRUCTIONS, BY CONNECTING THEM WITH THE MANIFESTATIONS OF DEITY IN THE SYSTEM OF NATURE, WOULD HAVE A TENDENCY TO ALLURE THE ATTENTION OF THE YOUNG TO RELIGIOUS SUBJECTS, AND TO AFFORD MENTAL ENTERTAINMENT, AND MORAI INSTRUCTION, TO INTELLIGENT MINDS OF EVERY DESCRIPTION.

NOVELTY and VARIETY appear to be essentially requisite in order to rouse the attention, not only of the more ignorant, but even of the more intelligent class of mankind, and to excite them to make progress in the path of intellectual and moral improvement. The principle of *curiosity*, which appears at a very early period of life, and which variegated scenery and novel objects tend to stimulate and to gratify—so far from being checked and decried, in a religious point of view, as some have been disposed to do, ought to be encouraged and cultivated in the minds both of the old and of the young. As it is a principle which God himself has implanted in our natures, for wise and important purposes, it requires only to be chastened, and directed in a proper channel, in order to become one of the most powerful auxiliaries in the cause of religion, and of intellectual improvement. To gratify this principle, and to encrease its activity, the Creator has adorned our globe with a combination of beauties and sublimities, strewed in endless variety over all its different regions. The hills and dales, the mountains and plains; the seas, the lakes, the rivers; the islands of every form and size which diversify the surface of the ocean; the bays, gulfs, and peninsulas; the forests, the groves, the deep dells and towering cliffs; the infinite variety of trees, plants, flowers, and vegetable productions of every hue, so profusely scattered over the face of

nature; the diversified productions of the mineral kingdom; the variegated colouring spread over the face of nature; together with the many thousands of different species of animated beings which traverse the air, the waters, and the earth—afford so many stimuli to rouse this principle into exercise, and to direct the mind to the contemplation of the Creator. And, as the earth displays an endless diversity of objects, so the heavens, in so far as they have been explored, exhibit a scenery both grand and variegated. There is not a planet in the Solar System but differs from another, in its magnitude, in its distance from the central luminary about which it revolves, in the velocity of its motion, in the extent of the circle it describes around the sun, in the period of time in which its revolution is completed, in its rotation round its own axis, in the number of moons with which it is attended, in the inclination of its axis to the plane of its orbit, and the diversity of seasons which result from this circumstance; in the density of its atmosphere, and the various appearances which diversify its surface. And, if we were favoured with a nearer view of these majestic orbs, we should, doubtless, behold a similar variety in every part of their internal arrangements.—The surface of the moon presents a variegated prospect of mountains and vales, but so very different in their form, position, and arrangement, from what obtains on the surface of our globe, that it would exhibit a scenery altogether new and uncommon to an inhabitant of this world, were we placed on the surface of that planet. Every comet too is distinguished from another, by its magnitude, the extent of its atmosphere, the length of its blazing tail, the rapidity of its motion, and the figure of the curve it describes around the sun. With regard to the fixed stars, which are distributed, of every size, and in every direction, through the immensity of space, our senses as well as the declaration of an inspired writer, convince us, that in point of brilliancy, colour, motion, and magnitude, "one star differeth from another star in glory." Almost every *Nebula* of the 3000 which have been discovered differs from another in its figure, extent, brightness, and general appearance; and the motions of double and treble stars, as to the periods of their revolutions, are as diversified as those of the planets—some of them revolving around their centres in thirty or forty years, others requiring 400, and even 1600 years to finish their circuits—some of them diffusing a bluish light, others a red, and others a brilliant white.

And as the system of nature, in all its parts, presents a boundless variety of scenery, to arouse the attention and to gratify the desire for novelty, so the revelation of God, contained in the Sacred Records, displays a diversified combination of the most sublime and interesting subjects and events. Were we to form an opinion of the compass of Divine Revelation, from the range of subjects to which the minds of some professing Christians are confined, it might all be comprehended within the limits of five or six chapters of the New Testament; and all the rest might be thrown aside, as a dead weight upon the Christian system. But here, as in all the other displays of the Almighty, divine perfection and providence are exhibited in the most diversified aspects. Here we have recorded a history of the creation and arrangement of our globe—of the formation of the first human pair—of their primeval innocence, temptation, and fall—of the arts which were cultivated in the first ages of the world—of the increase of human wickedness—of the building of the ark—of the drowning of the world by a universal deluge—of the burning of Sodom by fire from the clouds—of the origin of languages—of the dividing of the Red sea—of the journeyings of the tribes of Israel through the deserts of Arabia—of their conquest of the promised land, and their wars with the nations of Canaan—of the corporeal translation of Elijah from earth to heaven—of the manifestation of the Son of God in human flesh, the benevolent miracles he performed, and the triumphs he obtained over all the powers of hell and earth.—We are here presented with the most interesting and affecting narratives, elegies, dramatic poems, and triumphal songs,—with views of society in the earliest ages of the world, when the lives of men were prolonged to nearly a thousand years,—with splendid miracles performed in the land of Egypt, in the wilderness of Horeb, and in the "field of Zoan," when "the sun and moon stood still in their habitations;" when the waters of the great deep were divided, and mountains shook and trembled "at the presence of Jehovah,"—with the glorious marching of a whole nation through the Arabian deserts, under the guidance of a miraculous pillar of cloud and fire,—with the visits of celestial messengers, and the visible symbols of "a present Deity,"—with prophetical delineations of the present and future condition of the race of Adam, with descriptions of the Power, Wisdom, Love, and Majesty of the Almighty, and of his operations in Heaven and Earth, with the results and bearings of

the Economy of Redemption,—with Divine Songs, Odes, and Hymns, composed by angels and inspired men, with maxims of moral wisdom, examples of sublime eloquence, of strength of reasoning, and of manly boldness of reproof,—with Proverbs, Parables, Allegories, Exhortations, Promises, Threatenings, and Consolatory Addresses,—In short, we have here detailed, in the greatest variety —History, Antiquity, Voyages, Travels, Philosophy, Geography, Natural and Moral Science, Biography, Arts, Epic Poetry, Epistles, Memoirs, Delineations of Nature, Sketches of Human Character, Moral Precepts, Prophecies, Miracles, Narrations, Wonderful Providences, Marvellous Deliverances, the Phenomena of the Air, the Waters, and the Earth; the Past, the Present, and the Future Scenes of the World—all blended together in one harmonious system, without artificial order, but with a majesty and grandeur corresponding to the style of all the other works of God, and all calculated to gratify the principle of curiosity—to convey "reproof, correction, and instruction in righteousness," and "to make the man of God perfect, and thoroughly furnished to every good work."

And as the scenes of Nature and the scenes of Revelation are thus wonderfully diversified, in order to excite the attention of intelligent beings, and to gratify the desire for variety, so we have every reason to believe that the scenes, objects, and dispensations which will be displayed in the heavenly world will be incomparably more grand and diversified. When we consider the immensity of God's universal kingdom, and the numerous systems, and worlds, and beings comprehended within its vast circumference, and that the energies of Creating Power may be for ever exerted in raising new worlds into existence—we may rest assured that the desire of variety and of novelty, in holy intelligencies, will be completely gratified throughout an endless succession of existence; and that the most luxuriant imagination, in its boldest excursions, can never go beyond the reality of those scenes of diversified grandeur which the Heaven of heavens will display.

Now, since the Book of Nature and the Book of Revelation, since all the manifestations of the Creator in heaven and earth, are characterized by their sublime and diversified aspect—we would ask, why should we not be imitators of God, in displaying the diversified grandeur of his kingdom of Providence and Grace before the minds of those whom we profess to instruct? Why

should we confine our views to a few points of the Christian system, to a few stones in the fabric of the Divine operations, when "a wide and unbounded prospect lies before us"? Why should we not rather attempt to rouse the moral and intellectual energies of mankind, from the pulpit, from the press, in the school-room, and in the family circle, by exhibiting the boundless variety of aspect which the Revelations of Heaven present, and the holy tendencies of devout contemplation on the Works and the Ways of God—that they may learn, with due intelligence, to "meditate on *all* the works of the Lord, and to talk of *all* his doings"?—by enlarging and diversifying the topics of religious discussion according to the views now stated, we have it in our power to spread out an intellectual feast to allure and to gratify every variety of taste,—the young and the old, the learned and the unlearned, yea, even the careless and the ignorant, the sceptical and the dissipated, might frequently be allured by the selection of a judicious variety of striking and impressive objects and descriptions, to partake of those mental enjoyments which might ultimately issue in the happiest results. The man of an inquisitive turn of mind, who now throws aside every thing that has the appearance of religion, on account of its dullness, might have his curiosity gratified amidst such a variety as that to which I allude; and, from perceiving the bearing of every discussion on the great realities of religion and a future state, might be led to more serious enquiries after the path that leads to immortality. In a word, to associate and to amalgamate, as it were, the arts and sciences, and every department of useful knowledge with Divine subjects, is to consecrate them to their original and legitimate ends, and to present religion to the eyes of men in its most sublime and comprehensive and attractive form, corresponding to what appears to be the design of the Creator, in all the manifestations he has given of himself in the System of Nature, in the operations of Providence, and in the Economy of Redemption.

II.—BY CONNECTING SCIENCE WITH RELIGION, CHRISTIANS WOULD BE ENABLED TO TAKE AN EXTENSIVE SURVEY OF THE KINGDOM OF GOD.

How very narrow and limited are the views of most professors of religion respecting the universal kingdom of Jehovah, and the

range of his operations! The views of some individuals are chiefly confined within the limits of their own parish, or at farthest, extend only to the blue mountains that skirt their horizon, and form the boundary of their sight. Within this narrow circle all their ideas of God, of religion, and of the relations of intelligent beings to each other, are chiefly confined. There are others, who form an extensive class of our population, whose ideas are confined nearly to the country in which they reside, and to the adjacent districts; and there are few, comparatively, whose views extend beyond the confines of the kingdom to which they belong—though the whole island in which we reside is less than the two-thousandth part of the globe we inhabit. Of the vast extent of this earthly ball, of its figure and motions, of its continents, seas, islands, and oceans; of its volcanoes and ranges of mountains, of its numerous and diversified climates and landscapes; of the various nations and tribes of mankind that people its surface, and of the moral government of God respecting them,—they are almost as completely ignorant as the untutored Greenlander, or the roving savage.—With regard to the objects which lie beyond the boundary of our world, they have no precise and definite conceptions. When the moon is "walking in brightness" through the heavens, they take the advantage of her light to prosecute their journeys; and, when the sky is overcast with clouds, and they are anxious to travel a few miles to their destined homes, they will lift up their eyes to the heavens, to see if any of the stars are twinkling through the gloom that their footsteps may be directed by their glimmering rays. Beyond this they seldom soar. What may be the nature of the vast assemblage of shining points which adorn the canopy of their habitation, and the ends they are destined to accomplish in the plan of the Creator's operations, they consider as no part of their province to enquire.

> "Their minds fair Science never taught to stray
> Far as the Solar Worlds or Milky Way."

How very different in point of variety, of grandeur, and of extent, are the views of the man who connects all the different departments of knowledge, and the discoveries of science, with his prospects of God's universal dominion and government! With his mental eye he can traverse the different regions of the earth, and

penetrate into the most distant and retired recesses where human beings have their residence. He can contemplate and adore the conduct of Divine Sovereignty, in leaving so many nations to grope amidst the darkness of heathen idolatry,—he can trace the beams of the Sun of Righteousness, as they gradually arise to illumine the benighted tribes of men,—he can direct his prayers, with intelligence and fervour, in behalf of particular kindreds and people,—he can devise, with judgment and discrimination, schemes for carrying the "salvation of God" into effect,—he can realize, in some measure, to his mental sight, the glorious and happy scenes which will be displayed in the future ages of time, when "the kingdoms of this world shall become the kingdom of our Lord and of his Christ," and when the "everlasting gospel" shall be published, and its blessings distributed among all who dwell upon the face of the earth. He can bound from this earth to the planetary worlds, and survey far more spacious globes, peopled with a higher order of intelligences, arranged and superintended by the same Almighty Sovereign, who "doth according to his will among the inhabitants of the earth." He can wing his way beyond the visible region of the sky, till he find himself surrounded on every hand with suns and systems of worlds, rising to view in boundless perspective, throughout the tracts of immensity—diversified with scenes of magnificence, and with beings of every order—all under the government and the wise direction of Him who "rules among the armies of heaven," and who "preserveth them all," and whom the "host of heaven worship" and adore. He can soar beyond them all to the throne of God, where angels and archangels, cherubim and seraphim, celebrate the praises of their Sovereign Lord, and stand ready to announce his will by their rapid flight to the most distant provinces of his empire. He can descend from that lofty eminence to this terrestrial world, allotted for his temporary abode, and survey another unbounded province of the empire of God, in those living worlds which lie hid from the unassisted sight, and which the microscope alone can descry. He can here perceive the same Hand and Intelligence which direct the rolling worlds above, and marshal all the angelic tribes—organizing, arranging, and governing the countless myriads of animated existence which people the surface of a muddy pool. He can speed his course from one of these departments of Jehovah's kingdom to another, till, astonished and overwhelmed with the order, the grandeur, and ex-

tent of the wondrous scene, he is constrained to exclaim, "Great and marvellous are thy works, Lord God Almighty!" "Thine understanding is infinite!" The limits of thy dominions are "past finding out!"

By taking such extensive surveys of the empire of Jehovah, we are enabled to perceive the spirit and references of those sublime passages in the sacred writings which proclaim the majesty of God and the glory of his kingdom. Such passages are diffusely scattered through the inspired volume, and have evidently an extent of reference far beyond what is generally conceived by the great mass of the Christian world. The following may suffice as a specimen:—

"Thine, O Lord! is the greatness and the glory, and the majesty; for all in heaven and earth is thine! Thine is the kingdom, O Lord! Thou art exalted above all, thou reignest over all, and in thine hand is power and might.—Behold, the heaven and the heaven of heavens is the Lord's; the earth also, with all that therein is.—Ascribe ye greatness to our God; for there is none like unto the God of Israel, who rideth upon the heavens in his strength, and in his excellency in the sky. Thou, even thou art Lord alone; thou hast made heaven, the heaven of heavens, with all their host; the earth and all things that are therein; the sea and all that is therein; and thou preservest them all, and the host of heaven worshippeth thee.—He divided the sea by his power; by his Spirit he hath garnished the heavens: Lo! these are only parts of his ways; but how little a portion is heard of him, and the thunder of his power who can understand? The Lord hath prepared his throne in the heavens, and his kingdom ruleth over all. O Lord our God! how excellent is thy name in all the earth! who hast set thy glory above the heavens. When I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; what is *man* that thou art mindful of him!—His kingdom is an everlasting kingdom; honour and majesty are before him; *all the inhabitants of the earth are reputed as nothing in his sight*, and he doth according to his will in the armies of heaven and among the inhabitants of the earth.—He measures the waters in the hollow of his hand; he meteth out heaven with a span, and comprehendeth the dust of the earth in a measure.—He sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers.—I have made the earth and created man upon it; I, even

my hands have stretched out the heavens, and all their host have I commanded.—The Most High dwelleth not in temples made with hands; for the heaven is his throne and the earth is his footstool. With God is awful majesty.—Great things doth He which we cannot comprehend; yea, the Lord sitteth King for ever.—Praise ye the Lord in the heavens; praise him in the heights: praise him, all his angels; praise ye him, all his hosts. Praise him, sun and moon; praise him, all ye stars of light; praise him, ye heaven of heavens. Praise him, ye kings of the earth, and all people, princes and judges of the earth; both young men and maidens; old men and children—let them praise the name of the Lord; for his name alone is excellent, his glory is above the earth and heaven."

These sublime descriptions of the supremacy of God and of the grandeur of his kingdom, must convince every reflecting mind of the inconceivable magnificence and extent of that dominion "which ruleth over all." It is quite evident that we can never enter, with intelligence, into the full import and the grand references of such exalted language employed by inspired writers, unless we take into view all the discoveries which science has made, both in the earth and in the heavens, respecting the variety and extent of the dominions of the Creator. If the "kingdom of the Most High" were as limited in its range as most Christians seem to conceive, such descriptions might be considered as mere hyperboles or bombast, or extravagant declamation, which far exceeds the bounds of "truth and soberness." But we are certain that the conceptions and the language of mortals can never go beyond the reality of what actually exists within the boundless pre cincts of Jehovah's empire; for "who can utter the mighty acts of the Lord?" or "who can show forth *all* his praise?" The language and descriptions to which we have now adverted seem to have had a prospective reference to later and more enlightened times, when more extensive prospects of God's dominions would be opened up by the exertions of the human intellect. And were we to search all the records of literature, in ancient or modern times, we should find no descriptions nor language of such a dignified nature as to express the views and feelings, of an enlightened Christian philosopher, when he contemplates the sublimity and extent of Divine operations—except those which are to be found in the inspired volume—the strength, and majesty, and comprehension of which no human language can ever exceed.

Again, by familiarizing our minds to such extended prospects of God's universal kingdom, we shall be qualified and disposed to comply with the injunctions of Scripture, which represent it as an imperious duty *to communicate to the minds of others such elevated conceptions.* This duty is enjoined in numerous passages of sacred Scripture, particularly in the book of Psalms: "Declare his glory among the heathen, and his wonders among all people.—I will extol thee, my God, O King.—One generation shall praise thy works to another, and shall declare thy mighty acts.—I will speak of the glorious honour of thy majesty, and of thy wondrous works.—And men shall speak of the might of thy terrible acts, and shall declare thy greatness. All thy works shall praise thee, O Lord; and thy saints shall bless thee. *They shall speak of the glory of thy kingdom, and talk of thy power; to make known to the sons of men thy mighty acts, and the glorious majesty of thy kingdom?"* [1] When we look around us in the world, and in the visible church, and mark the conceptions and the conversation of the members of religious societies, we need scarcely say how little this ennobling duty is attended to by the mass of those who bear the Christian name. We hear abundance of idle chat about the fashions and the politics of the day; about balls, horse-races, court etiquette, theatrical amusements, contested elections, the squabbles of corporations, sectarian contentions, and ecclesiastical feuds. We listen to slanderous conversation, and hear abundance of mean, and base, and uncharitable insinuations against our neighbours; which indicate the operation of malice, hatred, envy, and other malignant dispositions. We spend whole hours in boisterous disputations about metaphysical subtilties, in religion, and questions "which gender strife rather than godly edifying:" but "to speak of the glory of God's kingdom," and to talk of his "POWER," with the view of "making known to the sons of men his mighty works," is a duty which remains yet to be learned by the majority of those who profess the religion of Jesus. Even sincere Christians, while "taking sweet counsel together,"—when conversing about the love of Christ, and "the deep things of God," and when endeavouring to cheer each other's spirits with the comforts of religion—seldom or never advert to the visible works of God, and the displays of his power and beneficence, as manifested in creation, from which they might derive additional comfort and support to their

[1] Psalm cxlv, and xcvi, 3, 4.

faith, hope, and joy, and more expansive views of the perfections and character of their Father and their friend. And how can they be supposed to be qualified to enter into the spirit of such exercises, and to proclaim to others "the glorious majesty of God's kingdom," unless such subjects be illustrated in *minute detail*, and proclaimed, with becoming energy, both from the pulpit and the press? These powerful engines, when conducted with judgment and discrimination, are capable of producing on the mass of mankind a tone of thinking and an enlargement of conception on such subjects which no other means can easily effect; and it is to be hoped that more precise and luminous details, and more vigour and animation, will soon be displayed in this respect than in the ages that are past.

There is a certain principle of *selfishness* which pervades the minds of many professed religionists, which leads them to conclude that, if they can but secure their own *personal salvation*, they need give themselves no trouble about the glory and extent of the kingdom of the Most High. "What need we care," say they, "about nations in the far-distant parts of the world, and about the planets and the stars? our business is to attend to the spiritual interests of our souls." Such persons seem neither to understand in what salvation really consists, and what is conducive to their spiritual interests, nor to appreciate those tempers and habits which will qualify them for the enjoyment of eternal life. It forms but a very slender evidence of their possessing any spark of Christianity at all, if they wish to rest satisfied with the most vague and grovelling conceptions, and if they do not ardently aspire after a more enlarged view of the attributes of God, of the glory of his empire, and of whatever may tend to expand their conceptions of the "inheritance of the saints in light." We have often been astonished at the opinions of some of those who move in a higher sphere of intelligence, who seem to consider it as a matter of *pure indifference* whether or not Christians should attain to the highest conception in their power of the God whom they worship, and of his boundless dominions; because they conceive that such views are not essentially connected with salvation! But we would ask such persons how they came to know that such views are not connected with salvation! Though they may not have been essential to the salvation of men in the dark ages that are past, or to the obscure tribes of people at present, who have no access to the proper sources of information, yet, since God, in the course of his

providence, which guides all human inventions and discoveries, has disclosed to us a far more expansive view of the "glory of his kingdom" than former ages could obtain, for the purpose of illustrating the revelations of his word, who will dare to assert that the man who has access, by his studious efforts, to contemplate this wondrous scene, and to display its grandeur to others, and yet wilfully shuts his eyes on the divine glory therein displayed, does not thereby hazard the Divine displeasure? In this point of view, the following passage deserves a serious consideration: "Because they regard not the works of the Lord, nor the operations of his hands, he shall destroy them, and not build them up." We have no hesitation in admitting that persons may have obtained salvation who never saw more of the sacred writings than what is contained in the gospel of Mark, or in one of Paul's epistles; but what should we say of the man who had access to all the revelations of heaven we now possess, and yet confined his attention solely to a chapter or two in the New Testament, and would not deign to look into any other part of the inspired volume? We should not hesitate at once to pronounce that such a person was grossly deficient in his duty, and devoid of that reverence and submission which are due to the oracles of God. And if it be admitted that the person who has access to the Bible, and who refuses to peruse its important contents, is guilty of a criminal neglect, we do not see how the man who has free access to the other volume of God's revelation, and views it as a matter of mere indifference whether he look into it or not, can be deemed in this respect entirely innocent. If it be understood that we shall be judged according to the light and privileges we enjoy, and the use we make of them in our improvement in the knowledge of God—we would deem it a hazardous position for any one to support, "That inattention to the visible glories of the kingdom of God, and to the 'declaration of his wonders among the people,' is a matter either of indifference or of trivial importance."

For, let it be considered further, that *on the extent of our views respecting the universal kingdom of God, depends our conceptions of the majesty and glory of the Creator himself.* We become acquainted with the nature of God only in so far as he has manifested himself to us by external operations,[1] and in so far as we form just con-

[1] Here I include the manifestation of Deity as exhibited both in Divine Revelation and in the System of Nature.

ceptions of these operations. If we conceive his empire as included within the bounds of eighty or ninety thousand miles, our conceptions of the Sovereign of that empire will be circumscribed within nearly the same limits. The mind of every reasonable man must indeed admit the abstract proposition, "That the Divine Being is infinite, and consequently fills all space with his presence." But this infinity, in our view, is nothing more than *a vague conception of empty space, extending a little way beyond the sphere of his visible operations.* The mind must have some material, visible, or tangible objects to rest upon, and to guide it in its excursions when it would attempt to form the most definite and comprehensive conceptions of an infinite, eternal, and invisible existence. For, however much we may talk about purely *spiritual ideas,* it is quite evident, from the nature of things, and from the very constitution of man, that we can have no ideas at all without the intervention of *sensible objects.* And therefore, if we would wish to form the most sublime conceptions of God himself, we must endeavour, in the first place, to take the most extensive views which science and revelation exhibit of his vast dominions. We must endeavour to form some adequate idea of the wide extent of the globe on which we dwell, its diversified scenery, and the numerous tribes of human beings and other animated existences, visible and invisible, which people its different provinces. We must explore the vast regions of the planetary system, and compare the bulk of the earth, large as it is, with some of those more magnificent globes which would contain within their circumference a thousand worlds as large as ours. We must next wing our way, in imagination, over a space which a cannon ball, flying five hundred miles every hour, would not traverse in ten hundred thousand years, till we arrive at the nearest fixed stars, and find ourselves in the centre of thousands of systems and worlds, arranged at immeasurable distances from one another. We must pass from one nebula, or cluster of systems, to another; continuing our excursions as far as the eye or the telescope can direct our view; and, when the aid of artificial instruments begins to fail, our imagination must still take its flight beyond the boundaries of mortal vision, and add system to system, and nebula to nebula, through the boundless regions of space, till we arrive at the grand centre of the universe, the Throne of God, around which all worlds and beings revolve, where "thousands of thousands" of bright intelligences "minister

to Him, and ten thousand times ten thousand stand before him."—We must consider all this magnificent assemblage of objects, not merely as so many masses of inert matter, or as a grand raree-show, to dazzle the eyes of a few hundreds of human spectators,—but as destined for purposes worthy of the plans and the intelligence of Him who is "the only wise God,"—as peopled with numerous orders of intelligent beings, whose physical and moral economy is superintended and directed by Him who, at the same time, rules amidst the tumults of human revolutions, and governs the living myriads which people a drop of water.

In this way, then, do we come to acquire the most extensive views of the amplitude and glory of the kingdom of the Most High; and it is only by the same process of thought that we can ever attain the most exalted conceptions of the attributes of its Almighty Sovereign. For our views of the Sovereign of the universe must always correspond with our views of the extent and magnificence of those dominions which sprung from his Creating Hand, and over which he every moment presides. His essence must for ever remain imperceptible to finite minds; for He is "the King Eternal, Immortal, and *Invisible*, dwelling in that Light which no man can approach unto, whom no man hath seen, or *can see*." From his nature, as a spiritual uncompounded substance, and from his immensity, as filling infinite space with his presence, it appears impossible, in the very nature of things, that the glory of his perfections can be displayed in any other way than through the medium of the visible operations of his hands, or in the dispensations of his providence towards particular worlds or classes of intelligencies. And if, in the future world, the souls of good men shall enjoy a more glorious display than at present of the attributes of the Deity, it will be owing chiefly to their being placed in more favourable circumstances than they now are for contemplating this display; to their faculties being more invigorated; and every physical and moral impediment to their exercise being completely removed; so as to enable them to perceive more clearly than they now do, the unbounded displays he has given of his infinite Power, Wisdom, and Benevolence. And, if we expect to be introduced to this state of enlarged vision when we pass from the scenes of mortality, it cannot be a matter of *mere indifference*, even now, whether or not our minds be prepared for such exalted employments, by endeavouring to form the most ample con-

ceptions of the attributes of God which can be obtained through the medium of his Word, and by a contemplation of the variety and magnificence of his Works.

In the prospect of that world where we hope to spend an interminable existence, it must also be interesting to ascertain, whether or not the dominions of the universal Sovereign present such an extent of empire, and such a variety of objects, that new scenes of wonder and glory may be expected to be displayed in continual succession, for the contemplation and entertainment of holy beings, while eternal ages are rolling on. And, on this point, the discoveries of science confirm and illustrate the notices of heavenly glory and felicity recorded in the inspired Volume, and lead us to rest with full assurance on the prophetic declaration, that "eye hath not seen, nor ear heard, nor hath it entered into the heart of man to conceive, the things which God hath prepared for them that love him."

III.—BY CONNECTING THE DISCOVERIES OF SCIENCE WITH RELIGION, THE MINDS OF CHRISTIANS WOULD BE ENABLED TO TAKE A MORE MINUTE AND COMPREHENSIVE SURVEY OF THE OPERATIONS OF PROVIDENCE

Providence is that superintendence and care which God exercises over all creatures and events, in order to accomplish the eternal purposes of his will. In *Creation*, God brought the universe out of nothing, and arranged all its provinces and inhabitants into due order. By his *Providence*, he supports and governs all the movements of the material system, and the sensitive and rational beings with which it is peopled. It is evident, that, in proportion as our views of the Creator's Dominions are extended, our views of his Providence will, to a certain extent, be proportionably enlarged. For, wherever worlds and beings exist, there will God be found preserving, superintending, and governing the movements of all creatures and events. It is chiefly, however, in the world in which we reside, that the diversified dispensations of Providence can be distinctly traced. Now, an acquaintance with the prominent parts of the different branches of knowledge to which I have already adverted, would enable us to take a particular and comprehensive view, not only of the ways of God to man, but also of his arrangements in reference to all subordinate creatures and events.

From the Inspired History of the Old Testament, we can trace the prominent lines of the dispensations of God towards man, particularly in regard to the Israelites and the surrounding nations —from the Creation to a period about 400 years before the coming of Christ. But in order to perceive the further progress and bearings of these lines till the commencement of the New Testament economy, we must have recourse to the most authentic records of profane history. From the era of the birth of Christ to near the close of the first century, we can acquire, from the Evangelists and the History of the Apostles, a particular account of the life of Christ, of the events which preceded and accompanied the finishing of the work of redemption, and the progress of the Gospel through Judea and the adjacent countries. But, after this period, we have no *inspired* guide to direct us in tracing the divine dispensations towards the various nations of the earth; and therefore we must have recourse to the annals, memoirs, chronicles, and other records of the history of nations, down to the period in which we live; otherwise we could never contemplate the continued series of events in the Divine economy towards the inhabitants of our world. Unless men of learning and of observation had recorded the prominent facts which have occurred in the history of nations, for 1800 years past we must have remained almost as ignorant of the dispensations of God towards our race, during that period, as the inhabitants of the planet Saturn; and unless we study the events thus recorded in the writings of the historian, and contemplate their various aspects and bearings in the light of Divine Revelation, we must still remain ignorant of the grand movements and tendencies of Divine Providence. This single circumstance shows, in the clearest light, that it is the intention of God that we should learn the operations of his providence from the researches of Science and of History as well as from the Records of Revelation; and that the Scriptures, though they contain every *supernatural* discovery requisite to our happiness, are not of themselves sufficient to present us with a connected view of the prominent dispensations of Heaven, from the Creation to the period in which we live.

From the science of *Geography* we acquire a knowledge of the extent of the surface of the earth—of the various tribes of human inhabitants with which it is peopled—of the physical aspect of the different climates they inhabit—of their arts, manners, cus-

toms, laws, religion, vices, wars, and political economy; and consequently we can, in these and similar respects, trace some of the aspects of Divine Providence towards them in relation to their present and future condition. From the same source we learn the number of human beings which the Governor of the world has under his direction at one time, which is nearly a thousand millions, or about four hundred times the number of the inhabitants of Scotland. From the data afforded by this science, we may also form an estimate of the number of disembodied spirits that have passed from this world since the Creation, and are now under the superintendence of the Almighty in the invisible state, which cannot be much less than 150,000 millions; and, on similar grounds, we may also learn the number of rational beings that are coming forward into existence, and passing into the eternal world every day, which is at least 68,000, and consequently nearly fifty during each passing minute,—every individual of which the Supreme Disposer of events superintends at his entrance into life; and, at his departure from it, directs to his respective and eternal state of destination. Hence it follows that, could we take a view of the whole system of animation on our globe with the eye of Omniscience, or even with the penetrating glance of an angelic being, we should behold *every hour* thousands of human and other animated beings incessantly emerging into existence, and thousands, at the same time, departing into an unseen world, under a vast diversity of circumstances; and this succession and exit of human beings will incessantly go forward from age to age, till all the designs of Providence in relation to our world be fully accomplished. All which circumstances, and many others of a similar kind, must be taken into account, in order to our forming a comprehensive conception of the numerous bearings and the incessant agency of a Superintending Providence.

From *Natural History* we learn the immense number and variety of the subordinate tribes of animated beings which inhabit the different regions of earth, air, and sea—their economy and instincts—their modes of existence, and the manner in which the Creator provides for their various necessities.—From an acquaintance with the *History of the Arts and Mechanical Inventions*, we learn the gradual manner in which God directs the movements of the human mind, in making those improvements and discoveries which have a bearing upon the accomplishment of his eternal plans of mercy,

and which tend to enlarge our views of the amplitude and the glories of his kingdom.—From *Natural Philosophy* and *Chemistry* we learn the secondary causes or subordinate laws by which the Almighty supports and directs the natural constitution of the world—the wonderful manner in which our lives are every moment supported—and the agencies by which fire, air, light, heat, and fertility are distributed through the globe, for promoting the comfort and happiness "of everything that lives."—From *Anatomy* and *Physiology* we learn how "fearfully and wonderfully we are made and preserved"—that our health and comfort depend upon the regular action of a thousand organical parts and functions over which we have no control—and that our very existence every moment is dependent on the superintendence of a Superior Power, "in whose hand our breath is, and whose are all our ways."

By an occasional study, then, of the subjects to which we have now alluded, we might gradually expand our conceptions of the range and operations of Divine Providence. Every geographical exploration of a new region of the globe—every scientific improvement and discovery—every useful invention—every eruption of a volcano—every shock of an earthquake—every hurricane and storm and tempest—every battle of the warrior—every revolution among the nations—and every detail in the newspapers we daily read, would lead us to form some conceptions of the providential purposes of Him who is the Supreme Disposer of all events.—Even the arrangements of Divine Wisdom, with regard to the economy of the lower animals, ought not to be overlooked in such a survey. When we consider the immense number and variety of animated beings—that there are 600 species of quadrupeds, every species containing, perhaps, many millions of individuals; 4000 species of birds; 3000 species of fishes; 700 hundred species of reptiles; and 44,000 different kinds of insects, besides many thousands of species altogether invisible to the unassisted sight—when we consider that the structure and organization of all these different species are different from each other, and exactly adapted to their various situations and modes of existence, and that their multifarious wants in regard to food and habitation are all provided for, and amply supplied by Him who, at the same time, arranges and governs the affairs of ten thousand worlds—we must be lost in astonishment at the greatness of the Intelligence which formed them, and at the exuberance of that bounty which spreads

so full a table for so immense an assemblage of living beings! And were we transported to other worlds, we should doubtless behold still more ample displays of Divine Beneficence.

We are here presented with a striking commentary on such passages of the Sacred Volume as these:—"The eyes of all look unto thee, O Lord! and thou givest them their meat in due season. Thou openest thy hand liberally, and satisfiest the desire of every living thing. The earth is full of thy riches, O Lord! so is the great and wide sea, wherein are things creeping innumerable, both great and small beasts. These all wait upon thee, and thou givest them their meat in due season. That which thou givest them they gather: Thou openest thine hand, they are filled with good." —"O Lord, thou preservest man and beast! How excellent is thy loving-kindness! Therefore the children of men shall put their trust under the shadow of thy wings. They shall be abundantly satisfied with the fatness of thy house,"[1] (of the table thou hast spread in thy world for all thine offspring,) "and thou shalt make them drink of the river of thy pleasures." One excellent practical effect which might flow from such contemplations would be to inspire us with feelings of humanity towards the inferior order of animals, and to prevent us from wantonly and unnecessarily torturing or depriving them of existence. For, since the Creator and Preserver of us all has so curiously organized their bodies, and fitted them for the different regions in which they reside, and so carefully provided for all their wants, it must be His will that they should enjoy happiness according to the extent of their capacities; and, therefore, they ought to be considered as necessary parts of our sublunary system.—Another practical lesson we may derive from such surveys, is, to place an unshaken dependence upon God for our temporal subsistence, while we at the same time exert all our faculties in the line of active duty. "Blessed is the man who trusteth in him; for there is no want to

[1] This and several other similar passages may be considered as more especially applicable to the bounty of Providence which God has provided for all his creatures. The practice of *spiritualizing* such passages, as it is termed, has a tendency to caricature Scripture, and to twist it from its precise and sublime references, to accord with the vague fancies of injudicious minds. The literal meaning of Scripture is always the most appropriate, emphatic, and sublime; but it may, in some cases, be used by way of accommodation, in illustrating Divine subjects, when it is applied with judgment and discrimination.

them that fear him. The young lions may suffer hunger, but they that fear the Lord shall not want any good thing."—He who decks the lily of the vale, and spreads out a plentiful table to the fowls of heaven, to the beasts of the forest, to the creeping insect, and even to the microscopic animalcule, will never fail to supply the necessary wants of those who "do His will and hearken to the voice of his commandments." And if at any time we be found destitute of daily food, and pining away in penury and squalid disease, we have too much reason to conclude that, in one way or another, either our deviation from the path of rectitude, or our distrust of Divine Providence, or our want of prudence and economy, has procured for us these things.

I have said that it is chiefly in the world in which we dwell that the dispensations of Providence can be distinctly traced. But we must nevertheless admit, that the care and superintendence of God are as minutely exercised in the distant regions of the universe as in our terrestrial sphere; though we are not permitted at present to inspect the particular details of His procedure in reference to other orders of intelligencies. We are not, however, altogether ignorant of some prominent features of the physical and moral economy of other worlds, in consequence of the discoveries of modern astronomical science.

With respect to their *physical* economy, we behold a striking variety in the Divine arrangements. We perceive one planetary world surrounded by two splendid and magnificent rings, one of them 204,000, and the other 184,000 miles in diameter, stretching across its celestial canopy from one end of the heavens to another—moving with majestic grandeur around its inhabitants every ten hours, and diffusing a light equal to several thousands of moons like ours—which may be considered as a visible and permanent emblem of the majesty and glory of their Creator. We perceive, connected with the same globe, seven moons, all larger than ours, of different magnitudes, and placed at different distances, and revolving in different periods of time around that spacious world. The diversified aspects of these rings, as viewed from the different regions of the planet at different times, and the variety of appearances produced by the alternate rising, setting, culmination, and frequent eclipses, and other aspects of the moons, must present to the inhabitants a very grand and diversified and magnificent scene of Divine operation. On the other hand, we

behold another planetary globe, destitute both of rings and moons, but which has the starry heavens presented to view nearly in the same aspect in which we behold them. We perceive a third globe, much larger than them both, capable of containing 200 times the number of the inhabitants of our world—accompanied in its course with four moons to diffuse light in the absence of the sun, and to diversify the aspect of its sky. In some of these worlds, the succession of day and night is accomplished within the space of ten hours; in others, this revolution is not completed till after the lapse of twenty-four hours, or of as many days. In some, the days and nights are nearly equal on every part of their surface, and they have little variety of seasons; in others, the variety in the length of the days and the vicissitude of the seasons are nearly the same as those we experience in our terrestrial world. Around some there appears a dense atmosphere, while others are environed with atmospheres more rare and transparent. Some move in the vicinity of the sun, and enjoy an abundant efflux of light and heat, while others are removed to the distance of 1800 millions of miles from that central luminary. Some finish the revolution of their year in a few months; while others require 12, 30, or even 80 of our years to complete their annual round. Some appear adorned with majestic mountain scenery, and others seem to have great changes occasionally taking place in their atmospheres, or on their surfaces. There are many planetary bodies lately discovered which, there is every reason to believe, once formed the component parts of a larger globe; but by some mighty catastrophe in the dispensations of Heaven, it appears to have been burst asunder into the fragments we now behold. If the general proposition illustrated in Section II. of the preceding Chapter be admitted, such a fact would seem to indicate that a moral revolution has taken place among the intelligent beings who had originally been placed in those regions; and that their fate was involved in the dreadful shock which burst asunder the globe they inhabited, just as the fate of the Antediluvians was involved in the shock by which the solid crust of our globe was disrupted, at the period of the universal deluge.

These are some outlines in the economy of Providence which we can trace with regard to the arrangements of other worlds; but beyond such general aspects we are not permitted to penetrate, so long as we sojourn in tabernacles of clay. But even such general

views afford some scope to the contemplative mind for forming enlarged conceptions of the grandeur and diversity, of the dispensations of God, in the worlds which roll in the distant regions of space.

With regard to their *moral economy*, we may rest assured that the prominent outlines of it are materially the same as of that economy which relates to the inhabitants of our world. The fundamental principles of the moral laws given to men, and which it is the great object of revelation to support and illustrate, are, "Thou shalt love the Lord thy God with all thy heart and understanding," and, "Thou shalt love thy neighbour as thyself." On these two commandments hang all the Law and the Prophets.—Now we must at once admit, from the nature of the Divine Being, and from the relations in which rational beings stand to Him and to one another, that the Creator has enacted these laws as the great governing principles by which the actions of all intelligences in heaven, as well as upon earth, are to be directed. For the Governor of the world can never be supposed to issue a law to any order of rational creatures, which would permit them to *hate* their Creator, or to hate those whom he has formed after his own image. Such a supposition would be inconsistent with the eternal rules of rectitude, and with the perfections of Deity; and the fact supposed, (if it could exist,) would introduce confusion and misery throughout the whole intelligent universe. And, therefore, we must necessarily admit that the laws to which I now advert are binding upon all the rational inhabitants which exist throughout Jehovah's dominions; and that it is by these that the moral order of all the Principalities and Powers of Heaven is preserved and directed. In those worlds where there is no change in the succession of their inhabitants—or, in other words, where there is no death, or where they are not produced by any process analogous to generation, but have a fixed and permanent residence—there will be no need for moral precepts corresponding to the Fifth and the Seventh Commandments of our moral law; and, in those worlds where property is common, and the bounties of the Creator are equally enjoyed by all, there will be no necessity for a law corresponding to the Eighth Commandment; but the general principles on which these laws are founded will be applicable to all the other circumstances and relations which actually exist; so that the *principle* and *spirit* and *essence* of our religion must be common to all

the holy inhabitants of the universe. And, therefore, it will follow that every intelligent being that is animated and directed by such principles and affections, will be qualified for holding delightful intercourse with all holy beings throughout the universe of God, in whatever province of the Creator's empire he may hereafter be placed; and, to qualify us for such harmonious and affectionate intercourses, is one great end of the salvation exhibited in the Gospel. So that, although we cannot, in our present state, acquire a minute and comprehensive knowledge of the moral history of other worlds, of the special interpositions or manifestations of Deity in relation to them, or of the means by which they are carried forward in moral and intellectual improvement—yet we can trace the *general* principles or laws which form the basis of their moral and religious economy. For, as the laws of optics and the principle of gravitation pervade the whole material system, as far as the universe is visible to our unassisted vision—so the principle of supreme love to God, and sincere affection to fellow-intelligences, must pervade the *intellectual* universe wherever it extends; and, if any intelligent agents besides men have violated these laws, they must experience pain and misery and disorders analogous to those which are felt by the inhabitants of our apostate world.

Thus I have endeavoured to show, that the combination of Science with Religion would tend to expand our views of Divine Providence—in the various arrangements of God, in relation to the human race, and to the subordinate tribes of sensitive beings—and in reference to some of the prominent features of his administration in distant worlds. And, therefore, though the Christian ought never to overlook the ways of Providence in relation to himself, and to his spiritual and domestic concerns, yet it would argue a selfishness and a sottishness altogether inconsistent with the noble and expansive spirit of Christianity, to overlook all the other parts of the Theatre of Divine Dispensations, when a very slight degree of labour and research might be instrumental in unfolding them to his view.

IV.—THE CONNEXION OF SCIENCE WITH RELIGION WOULD HAVE A TENDENCY TO INDUCE IN CHRISTIANS A SPIRIT OF LIBERALITY, OF CANDOUR, AND OF ACCURACY IN JUDGING OF THE OPINIONS AND ACTIONS OF MEN, AND OF THE DIVINE PROCEDURE AND OPERATIONS.

Who is the most Candid and Liberal Being in the universe? God.—And why is God to be considered as the most Liberal Intelligence that exists? Because He embraces a minute, a full, and comprehensive view of all the circumstances, connections, relations, habits, motives, temptations, modes of thinking, educational biases, physical affections, and other causes, that may influence the sentiments or the conduct of any of his creatures.—Who, among created intelligences may be viewed as endowed with these qualities in the next degree? The loftiest seraph that God has created, who has winged his way to numerous worlds; and taken the most extensive survey of the dispensations of the Almighty, and of all creatures and events.—Who, among the sons of men, is the most illiberal and inaccurate in judging of opinions, of persons, and of things? The man who has lived all his days within the smoke of his father's chimney, or within the confines of his native village—who has never looked beyond the range of his own religious party—whose thoughts have always run in one narrow track—whose reading has been confined to two or three musty volumes, which have lain for ages on the same smoky shelf—who cares for nothing either in the heavens or the earth, but in so far as it ministers to his convenience, his avarice, or his sensual enjoyment—who will admit no sentiment to be true but what he may have heard broached by his parson—and whose conversation seldom rises beyond mere gossiping chit-chat, and the slanderous remarks which are circulated among his neighbours. Such characters are entirely unqualified for forming a correct judgment, either of the sentiments and the actions of men, or of the works and the ways of God; for they are completely destitute of the requisite *data* whereon to form a rational decision in relation to either of these subjects.

It may be admitted as a kind of axiom, in our estimate of human character, that, in proportion to the ignorance, and the narrow range of view which characterise any individual, in a similar proportion will be his want of candour, and his unfitness for

passing a sound judgment on any subject that is laid before him—and that the man who has taken excursions through the widest range of thought, accompanied with a corresponding improvement of his moral powers, will always be the most liberal and candid in his decisions on the moral and intellectual qualities of others. To these maxims, few exceptions will generally be found.—In forming an enlightened judgment in regard to any action or object, it is essentially requisite, that we contemplate it in all its different features and aspects, and in all its minute circumstances, bearings, and relations. We would not hesitate for a moment to determine who is best qualified to give an accurate description of a city,—he who has only viewed its spires from a distance, while in rapid motion in his chariot—or he who has minutely surveyed all its streets, lanes, squares, public edifices, and surrounding scenery, in every variety of aspect; or, who appears most likely to form the most accurate and enlightened judgment in relation to any particular kingdom,—he who has just skirted along a few miles on one of its coasts, or he who has traversed its length and breadth in all directions, and mingled with every class of its inhabitants. On the same principle it must be admitted, that he who has viewed religion in all its aspects and bearings, who has taken the most extensive survey of the manifestations of God, and of the habits and relations of men, is the best qualified to pronounce a candid and accurate decision on all the intellectual and moral cases that may come before him.

If the spirit of the above-stated sentiments be founded on reason and on fact, it will follow that, the more we resemble God in the amplitude of our intellectual views and benevolent affections, the more candid, and liberal, and accurate will our judgments be in reference to all the actions, objects, and relations we contemplate. On the other hand, the man who is confined to a narrow range of thought and prospect, is continually blundering in the estimates he forms, both in respect to physical facts, to general principles, and to moral actions. He forms a premature and uncharitable opinion on every slander and report against his neighbour. He condemns without hesitation, and throws an unmerited odium on whole bodies of men, because one or two of their number may have displayed weakness and folly. He hates and despises men and their opinions, because they belong not to his political or religious party. He pronounces his decisions on the motives of men with as much

confidence as if he had surveyed their hearts with the eye of Omniscience. He cannot hear an objection against his favourite opinions with patience, nor an apology for any set of principles but his own. He is arrogant and dogmatical in his assertions, and will make no concessions to the superior wisdom of others He sets himself, with violence, against every proposal for reformation in the church, because his forefathers never thought of it, and because such "innovations" do not suit his humour and preconceived opinions. He decides, in the most confident tone, on what God *can* and *cannot* do, as if he had taken the guage of infinite perfection; and he frets at the Divine dispensations when they do not exactly quadrate with his own humour and selfish views.

With regard to the operations of the Most High he also forms the most foolish, and vague, and contradictory conceptions. Tell him of the vast dimensions of the planetary system, of the men and animals that live on the opposite side of the globe, of the annual and diurnal motion of the earth—that this world and its inhabitants are moving through the regions of space many thousands of miles every hour—that one of the planets is so large that it would contain 1400 worlds as spacious as ours—that another is flying through the tracts of immensity at the rate of a hundred thousand miles in an hour—and that light is darted from the sun with a velocity of 192,000 miles in a moment of time,—he will stare at you with astonishment at such extravagant assertions, and will sooner believe the stories of giants 100 feet high, and of fairies that can enter in crowds through the keyhole of his door. Instead of frankly acknowledging that "he is ignorant of such subjects, and of the grounds of such conclusions—that those that have studied them with intelligence are best capable of judging—that, if true, they must fill us with admiration of the glory of God—but that, as he has hitherto had no opportunity of examining such matters, he must suspend his assent till he enquire into the reasons which can be given for such amazing deductions." Instead of such concessions, which are the dictates of modesty and of common sense, he will tell you at once, without hesitation, and without a blush at his presumptuous decisions, that "it is all extravagance and folly and idle romance, contrary to Scripture and reason and common sense;" and will not hesitate to brand you as a heretic, for endeavouring to break loose his intellectual trammels!—thus tacitly declaring that he is far better qualified to pro-

nounce a decision on such topics than all the philosophers and divines, and all the brightest geniuses who have appeared in the world for ages past; though he will at the same time admit, that he never gave himself the trouble to examine into such matters!

His views of the providential dispensations of God are equally partial and distorted. If disease, or poverty, or misfortune, happen to his neighbour, especially if he had withdrawn from the religious party to which he belongs, it is considered as a penal judgment for his error and apostacy. If prosperous circumstances attend his family or his religious party, it is viewed as a sign of Divine approbation. He seldom views the hand of God, except in uncommon occurrences; and then, he imagines that a miracle is performed, and that the wheels of nature are stopped in order to accomplish the event. He seldom looks beyond the precincts of his own church or nation, to observe the movements of the Divine footsteps towards other tribes of his fallen race. He overlooks the traces of Divine operation which are every moment to be seen above and around him—and yet, in the midst of all such partial and contracted views, he will sometimes decide on the Wisdom and Rectitude of the Ways of God, with as much confidence as if he had entered into the secret councils of the Eternal, and surveyed the whole plan of his procedure.

Such are a few prominent outlines of the character of thousands, whose names are enrolled as members of the visible church—whose illiberality and self-conceit are owing to the contracted notions they have formed of God and of Religion. And surely, it must appear desirable to every enlightened Christian, that every proper means should be used to prevent rational immortal beings from remaining enchained in such mental thraldom.

On the other hand, the man who takes an enlightened view of all the works and dispensations of God, and of all the circumstances and relations of subordinate beings, necessarily acquires a nobleness and liberality of mind, and an accuracy in judging of things human and divine, which no other person can possess. He does not hastily take up an evil report against his neighbour; for he considers how unfounded such reports often are, and how much they are owing to the insinuations of envy or of malice. And, when he can no longer doubt of an evil action being substantiated against any one, he does not triumph over him in the language of execration; for, he considers all the circumstances,

relations, feelings, and temptations with which he may have been surrounded; he considers, that he himself is a frail sinful creature, and might possibly have fallen in a similar way, had he been placed in the same situation. He does not trumpet forth the praises of a man who has performed *one* brilliant benevolent deed, as if he were a character to be admired and eulogised—while the general course of his life is marked with vice, and an utter forgetfulness of God and Religion; nor does he fix a stigma of immorality upon the person who may have acted foolishly or sinfully in one or two instances, while the general tenor of his conduct has been marked by purity and rectitude: for, in both cases he considers, that it is not an *isolated action*, but *general habits*, which determine the character of any individual. He esteems the Wise and the Good, and holds friendly intercourse with them, to whatever political or religious party they belong. He can bear, with affability and candour, to have his opinions contradicted, and can differ from his neighbour in many disputed points, while, at the same time, he values and esteems him. He will not brand a man as a Heretic or a Deist, because he takes a view of some dogmas in Theology in a different light from what he himself does; for he considers the difference of habits, studies, pursuits, and educational prejudices, which must have influenced his opinions; and makes due allowance for the range of thought to which he may have been accustomed. He is always disposed to attribute the actions of others to good motives, when he has no proof to the contrary. He uses no threats nor physical force to support his opinions, or to convince gainsayers; for he knows that no external coercion can illuminate the mind, and that the strength of arguments, and the force of truth, can alone produce conviction. He is convinced how ignorant he is, notwithstanding all his study, observations, and researches, and presses forward, as long as he lives, to higher degrees of knowledge and of moral improvement.

He is an active promoter of every scheme that tends to enlighten and meliorate mankind, and to extend the knowledge of salvation to the ends of the earth; for he considers that it is not by miracles, but by the subordinate agency of intelligent beings, that God will effectuate the illumination and the moral renovation of our apostate race. He views the special agency of God in all the movements of the Scientific, the Religious, and the Political world, and perceives Him accomplishing his purpose, in the inventions of

human genius, and in the economy of the minutest insect, as well as in the earthquake, the storm, and the convulsions of nations; for he considers the smallest atom, and the Hosts of Heaven, as equally directed by Eternal Wisdom, and equally necessary in the universal chain of creatures and events. He displays a becoming modesty in speaking of the ways and the works of God. When he meets with any dark and afflictive dispensation in the course of Providence, he does not fret and repine, but is calm and resigned, conscious that he perceives only a small portion of the chain of God's dispensations, and is, therefore, unable to form a just comparison of the connexion of any one part with the whole. When he contemplates the depraved and wretched condition of the greater part of the world, at present, and for thousands of years past, notwithstanding the salvation which has been achieved for sinners of mankind, he is far from arraigning the Divine goodness and rectitude, in leaving so many nations "to walk in their own ways;" for he knows not what relation this dismal scene may bear, what influence it may have, or what important impressions it may produce, on worlds and beings with which we are at present unacquainted.

He is cautious in pronouncing decisively respecting the dispensations of God, *in regard to the universe at large.* He admires and adores the Condescension and the Love of God, in the plan of Salvation which the Gospel exhibits, and feels an interest in it far beyond that of any other special manifestation of Deity; but he dares not set limits to the Divine Attributes and Operations. He considers himself at present, with regard to the grand system of the Universe, in a situation similar to that of a small insect on one of the stones of a magnificent edifice, which sees only a few hair-breadths around it, and is altogether incapable of surveying the symmetry, the order, and beauty of the structure, and of forming an adequate conception of the whole. He considers that he has never yet surveyed the millionth part of Jehovah's empire, and, therefore, cannot tell what the Eternal Sovereign has been pleased to exhibit in its numerous provinces; and, least of all, can he ever presume to dive into the depths of interminable ages, and boldly declare what the Almighty will, or will not do, through eternity to come. In short, he endeavours to take a view of all the manifestations of Deity within his reach, from every source of information which lies before him, and as far as his limited facul-

ties will permit. He does not call in question the discoveries of Science, because they bring to his ears most astonishing reports of the Wisdom and Omnipotence of Jehovah; and of the boundless extent of his kingdom; but rejoices to learn, that the grandeur of his dominions is actually found to correspond with the lofty descriptions of Divine Majesty and Glory recorded in the volume of Inspiration, and is thereby inspired with nobler hopes of the glory and felicity of that heavenly world where he expects to spend an endless existence.

If, then, such be some of the features in the character of the enlightened Christian; if liberality and candour, and accurate in vestigation, mark the judgments he pronounces on the sentiments and the actions of men, and on the works and ways of God; and if such views and feelings ought to be considered as more congenial to the noble and benevolent spirit of our religion, than the narrow and distorted notions of a contracted mind,—it must be an object much to be desired, that the mass of the Christian world be led into such trains of thought, as might embue their minds with a larger proportion of this spirit. And, if diversified and occasional discussions on the topics to which we have adverted would have a tendency to produce this desirable effect, it is obvious, that such branches of knowledge as are calculated to enlarge the capacity of the mind, and to throw a light over the revelations and the works of God, should no longer be overlooked in the range of our religious contemplations.

V.—THE EXTENSIVE RANGE OF THOUGHT WHICH THE DIVERSIFIED OBJECTS IN NATURE PRESENT, WOULD HAVE A TENDENCY TO INSPIRE US WITH A SPIRIT OF PIETY AND PROFOUND HUMILITY.

It is owing, in many instances, to want of attention to the impressive displays of Wisdom and Omnipotence in the material world, that our pious feelings and devotional exercises are so cold and languid. We stalk about on the surface of the earth, and pass from one day to another, without reflecting on the grand and complicated machinery around us, which is carrying us along through the regions of space, and from one portion of duration to another, as if the mighty energies of the Eternal Mind, exerted in our behalf, were unworthy of our acknowledgment or regard. How few, for example, reflect, when they open their eyes in the

morning, and perceive the first beams of the rising sun, that, since they lay down to sleep, the Divine Power has been exerted in carrying them more than four thousand miles round to the eastward, in order that they might again be cheered with the morning light; and that, during the same period, they, along with the earth and its vast population, have been carried forward 476,000 miles from that portion of space which they occupied seven hours before?[1] Or, if they have no idea of the motion of the earth, and attach no belief to such an opinion, how is it they do not reflect, that, after night has thrown its shades around them, the sun, and ten thousand other vast globes, must move several hundreds of millions of miles, before their eyes can again behold the light of day! Either the one or the other of these cases *must be the fact;* and, in either case, there is presented to our view, a display of the Omnipotence and the Superintendence of Him in whom we live and move, which demands our gratitude, our admiration, and praise. And can it ever be supposed, that such reflections, combined with all the other excitements to reverence and gratitude, will not tend to elevate our contemplations, and to raise our pious feelings to a higher pitch of devotion? Whether the Psalmist entertained any views of this kind, when he composed the ninety-second Psalm, we cannot certainly determine; but I presume, the pious and contemplative mind, when awakening from the slumbers of the night, under such impressions, might sing the first part of that song of praise with peculiar emphasis and delight—"It is a good thing to give thanks to Jehovah, and to sing to thy name, O, thou Most High! to show forth thy loving-kindness in the morning. For

[1] When it is here said that we are carried "more than 4000 miles round to the eastward" during the hours of sleep—the author refers to the *diurnal* motion of the earth from west to east. The rate of this motion is different to the inhabitants of different latitudes. At the Equator the inhabitants are carried at the rate of 1038 miles an hour, and if seven hours be allowed for nightly repose, they are carried round 7266 miles during sleep. Those who live in the 52nd degree of latitude, as the inhabitants of places near London, move at the rate of 637 miles an hour; and consequently, in the course of seven hours, are carried round 4459 miles. The inhabitants of Greenland, in lat. 69°, during the same time, move only 2570 miles; and were there any inhabitants at the 88th degree of latitude, or within two degrees of the polar points, their motion, during seven hours, would not exceed 252 miles.---When it is said we are carried forward during the same time, 476,000 miles, the reference is to the *annual* motion of the earth, which is at the rate of sixty-eight thousand miles every hour, and consequently 476,000 miles during the seven hours supposed to be allotted to sleep.

thou, Lord, hast made me glad through thy work" (or thy powerful energy,)—"I will triumph in the works of thy hands. O Lord! HOW GREAT ARE THY WORKS! and thy thoughts" (or contrivances) "are very deep! A brutish man knoweth not, neither doth a fool understand this."

An extensive acquaintance with nature and science, combined with Christian principle, would also induce *profound humility.* The man, who has made excursions through the most diversified regions of thought, is deeply sensible of the little progress he has attained, and of the vast and unbounded field of Divine science which still remains to be explored. When he considers the immense variety of sublime subjects which the Volume of Inspiration exhibits, and of which he has obtained but a very faint and imperfect glimpse—the comprehensive extent, and the intricate windings of the operations of Providence, and the infinite number of beings over which it extends—the amplitude and magnificence of that glorious universe over which Jehovah presides, and how small a portion of it lies open to his minute inspection—he is humbled in the dust at the view of his own insignificance; he sees himself to be a very babe in knowledge; and, as it were, just emerging from the gloom of ignorance into the first dawnings of light and intelligence. He feels the full force and spirit of the poet's sentiments—

"Much learning shows *how little* mortals know."

When he considers the comprehensive extent of the Divine law and its numerous bearings on every part of his conduct, and on all the diversified relations in which he stands to his God, and to his fellow-men; and when he reflects on his multiplied deviations from that eternal rule of rectitude, he is ashamed and confounded in the presence of the Holy One of Israel; and on a review of his former pride and self-conceit, is constrained to adopt the language of Agur and of Asaph—"Surely I am more brutish than any man, and have not the understanding of a man." "So foolish was I, and *ignorant,* I was as a beast before thee." He views the meanest and the most ignorant of his species, as but a few degrees below him in the scale of intelligence, and sees no reason why he should glory over his fellows.

This sentiment might be illustrated from the example of some of the most eminent men in whose minds science and religion were combined. The Honourable Mr. BOYLE was the most unwearied and successful explorer of the works of God, in the age in which

he lived, and all his philosophical pursuits were consecrated to the service of Religion. Among the excellent traits in his character, HUMILITY was the most conspicuous. "He had about him," says Bishop Burnet, "all the unaffected neglect of pomp in clothes, lodging, furniture, and equipage, which agreed with his grave and serious course of life," and was courteous and condescending to the meanest of his fellow-men. "He had," says the same author, "the profoundest veneration for the great God of heaven and earth that ever I observed in any person. The very *name* of God was never mentioned by him without a pause, and a visible stop in his discourse; and the tenor of his philosophical and theological writings is in complete unison with these traits of character.—Sir ISAAC NEWTON, too, whose genius seemed to know no limits but those of the visible universe, was distinguished by his *modesty*, *humility*, and *meekness* of temper. He had such an *humble* opinion of himself, that he had no relish of the applause which was so deservedly paid him. He would have let others run away with the glory of his inventions, if his friends and countrymen had not been more jealous of his honour than he was himself. He said a little before his death, "I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

The same sentiment might have been illustrated from the lives of Bacon, Locke, Dr. Boerhaave, Hervey, Nieuwentyt, Ray, Derham, the Abbe Pluche, Bonnet, and other eminent characters, who devoted their stores of knowledge to the illustration of the Christian system. For an *extensive* knowledge of the operations of God has a *natural tendency* to produce humility and veneration; and wherever it is combined with pride and arrogance, either among philosophers or divines, it indicates a lamentable deficiency, if not a complete destitution, of Christian principle, and of all those tempers which form the bond of union among holy intelligences. After the attention of Job had been directed to the works of God, and when he had contemplated the inexplicable phenomena of the Divine agency in the material world, he was ashamed and confounded at his former presumption; and, in deep humility, exclaimed, "I have heard of thee by the hearing of the ear; but now mine eye seeth thee; wherefore I abhor myself, and repent in dust and ashes."—In accordance with what has been now stated,

we find, that the most exalted intelligences, who, of course, possess the most extensive views of the works and providential arrangements of God, are represented as also the most humble in their deportment, and as displaying the most profound reverence in their incessant adorations. They "*fall down* before him who sits upon the throne; and *cast their crowns before the throne*, saying, Thou art worthy, O Lord, to receive glory, and honour, and power; for thou hast created all things, and for thy pleasure they are and were created." Their moral conduct evinces the same lowly temper of mind. They wait around the throne, in the attitude of motion, with wings outspread, ready to fly, on the first signal of their Sovereign's will; they "do his commandments, hearkening to the voice of his word," and do not disdain to perform important services, in our wretched world, to the meanest human being who is numbered among "the heirs of salvation." In like manner, were *we* indued with the grasp of intellect, the capacious minds, the extensive knowledge, and the moral powers which they possess, we would also display the same humble and reverential spirit, and feel ashamed of those emotions of vanity and pride, which dispose so many of the human family to look down with contempt on their fellow-mortals.

If the leading train of sentiment which pervades this work be admitted, the following GENERAL CONCLUSIONS may be deduced:—That, in conducting the religious instruction of the young, the works of God in the material world, and the most striking discoveries which have been made as to their magnitude, variety, and mechanism, should be frequently exhibited to their view, *in minute detail;* as illustrations of the attributes of the Deity, and of those descriptions of his nature and operations contained in the Volume of Inspiration;—that the books put into their hands should contain, among other subjects, popular and striking descriptions of the facts and appearances of nature;—that seminaries should be established for the occasional instruction of young persons, from the age of fifteen to the age of twenty or thirty, or upwards, in all those popular branches of natural and moral science which have a tendency to enlarge the capacity of their minds, and to expand their conceptions of the incessant agency of God;—and that the Ministers of Religion, in their public instructions, should frequently blend their discussions of divine topics with illustrations derived from the scenes of Creation and Providence.

APPENDIX:

CONTAINING

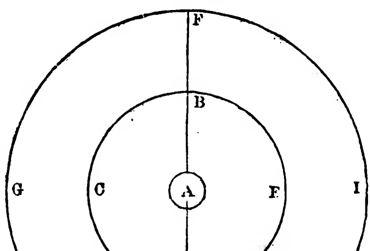
NOTES AND ILLUSTRATIONS.

NOTE I, p. 53.—*Illustration of the rate of Motion in the Heavenly Bodies, on the supposition that the Earth is at rest.*

THE distance of the sun is about 95 millions of miles; consequently, the diameter of the circle he would describe around the earth would be 190 millions, and its circumference 597,142,857, which forms the extent of the circuit through which he would move in 24 hours, if the earth were at rest. This number, divided by 24, gives 24,880,952, the number of miles he would move in an hour; and this last number divided by 60, gives 414,682, the number of miles he would move in a minute. The nearest star is reckoned to be at least 20,000,000,000,000, or twenty billions of miles distant from the earth; consequently, its daily circuit round our globe would measure more than 125,000,000,000,000 miles. This sum, divided by 86,400, the number of seconds in a day, would give, 1,454,861,111, or somewhat more than one thousand four hundred millions of miles, for its rate of motion in a second of time,—a motion, which, were it actually existing, would, in all probability, shatter the universe to atoms.

The unlearned reader may, perhaps, acquire a more distinct idea of this explanation in the following figure:—

FIG 45.



Let the small circle A, in the centre, represent the Earth, and the circle B C D E the orbit of the Sun, on the supposition that he moves round the earth every 24 hours. The line A B will represent the distance of the Sun from the Earth, or 95 millions of miles. The line B D the *diameter* of the orbit he would describe; and the circle B C D E the circumference along which he would move every day, or 597 millions of miles, which is somewhat more than three times the diameter. If the line A F represent the distance of the nearest star, the circle F G H I will represent the circuit through which it would move every 24 hours, if the earth were at rest. It is obvious from the figure that since the stars are at a greater distance from the earth than the sun, the circle they would describe around the earth would be larger in proportion, and, consequently, their velocities would be proportionately more rapid; since they would move through their larger circles in the same time in which the sun moved through his narrower sphere. But, the supposition that the earth is the centre of all the celestial motions, and that the different stars are daily moving round it with different velocities, and the slowest of these motions so inconceivably rapid, is so wild and extravagant, that it appears

altogether inconsistent with the harmony of the universe, with the wisdom and intelligence of the Deity, and with all the other arrangements he has made in the system of nature.

NOTE II, p. 84.—*Experimental Illustrations of the Pressure and Compressibility of the Atmosphere.—The Diving Bell, etc.*

The pressure of the atmosphere is most strikingly illustrated by means of the air-pump. But as few persons, comparatively, possess this instrument, the following experiments, which any person may perform at pleasure, are sufficiently convincing on this point. Take a common wine glass, and fill it with water; apply a piece of paper over the mouth of the glass; press the paper to the rim of the glass with the palm of the hand; turn the glass upside down; withdraw the hand from the paper; and the water will be supported by the pressure of the atmosphere. That it is the atmospherical pressure, and not the paper, which supports the water, is evident; for the paper, instead of being pressed down by the weight of the water, is pressed upward by the pressure of the atmosphere, and appears *concave*, or hollow in the middle. If the flame of a candle be applied to the paper, it may be held for an indefinite length of time close to the paper, without setting fire to it. The same fact is proved by the following experiment:—Take a glass tube, of any length, and of a narrow bore; put one end of it in a basin of water; apply the mouth to the other end, and draw out the air by suction; the water will immediately rise towards the top of the tube; and if the finger or thumb be applied to the top of the tube, to prevent the admission of air, and the tube removed from the basin of water, the water in the tube will be supported by the pressure of the atmosphere on the lower end; Again:—Take a wine glass, and burn a small bit of paper in it; and while the paper is burning, press the palm of the hand upon the mouth of the glass, and it will adhere to the hand with considerable force. In this case the pressure of the atmosphere will be *sensibly* felt; for it will sometimes require a considerable force to detach the glass from the hand.

The following experiment will also illustrate the pressure of the atmosphere. Take a tin vessel about six or seven inches long and three in diameter with its mouth about a quarter of an inch wide, as E F in Fig. 46. Pierce a number of small holes in its bottom, about the diameter of a common sewing needle. Plunge the vessel in water; and when full, cork it up, so that no air can enter at top. While it remains corked no water will run out, being prevented by the atmospheric pressure, but the moment it is uncorked, the water will issue from the small holes in the bottom by the pressure air from above.—The same experiment may be made by taking a tube, G H, Fig. 47, seven or eight inches long, and about three-fourths of an inch diameter, having a small hole on each side, I K. When filled with water and corked no water will run out, but when the cork is removed the water will run out at I and K, illustrating the *lateral* pressure of the atmosphere. This experiment explains the reason of ale, etc., not running from the tap till the removal of the spiggot.

The pressure of the atmosphere explains a variety of common phenomena. When we take a draught of water out of a basin or a running stream, we immerse our mouth in the water, and make a vacuum by drawing in the air; the pressure of the atmosphere upon the external surface of the water then forces it into the mouth. The same cause explains the process of a child sucking its mother's breasts—the action of a boy's sucker in lifting large stones—the rise of water in pumps—the effects produced by *cements*—the firm adhesion of snails and periwinkles to rocks and stones—the scarcity of water in the time of hard frosts—and the fact, already mentioned, that a cask will not run by the cock, unless a hole be opened in some other part of the cask.

The following experiment illustrates the *compressibility* of air and at the

same time the principle upon which the *Diving Bell* is constructed. Let A B, Fig. 48, represent a large tumbler, nearly filled with water. Place a piece of cork on the surface of the water, and over the cork an ale-glass, C D, with its

FIG. 46.

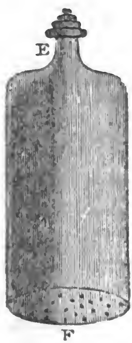


FIG. 47.

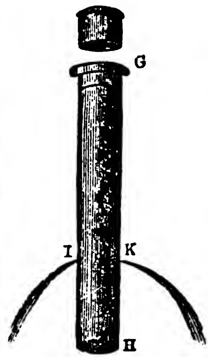
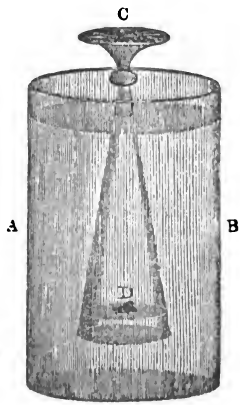


FIG. 48.



mouth downwards: then push the glass perpendicularly down towards the bottom of the tumbler, and the cork will appear swimming a little above the bottom—indicating that there is no water above it in the ale-glass, but only *air*, which prevents the entrance of the water. If the water in the tumbler be supposed to represent the water of a river or of the sea, the ale-glass will represent the diving bell in which a person may sit with safety in the depths of the sea without danger, provided fresh air be supplied. A small quantity of water will be found to have entered the ale-glass, and the deeper it is plunged in any vessel the higher will the water rise within it; which proves the *compressibility* of the air within the glass.

The diving bell has been much used of late in recovering valuable articles from the wreck of ships that had sunk in deep waters, and in blowing up such wreck as are sunk near the mouths of rivers, and form impediments to navigation—by means of powder ignited by the electric spark.—Such inventions as that now stated may be applied to practical and beneficial purposes, and perhaps to purposes more diversified and extensive than we can in the mean time anticipate. The diving bell has lately been employed in the harbour of Sebastopol, with a view to the recovery of the sunken ships of war belonging to Russia.

NOTE III.—*On the ideas of Magnitude, Motion, and Duration, as expressed by Numbers* Pages 114, 120, etc.

In the pages referred to and in other parts of this work some very large numbers are expressed in *figures*. Some readers have insinuated, that it would have been better to express such numbers in *words*. The author, however, is of a different opinion; because, to some readers not much acquainted with *Numeration*, a thousand *trillions* would convey nearly the same idea as a thousand *nonillions*, though the one number contains fifty-eight places of figures, and the other only twenty-two. It is chiefly the number of figures, or ciphers, in such

large sums, that leads us to form a comparative estimate of their value or extent. Our ideas of magnitude and extension, conveyed by such numbers, must, of course, be very vague and undefined. If we have been accustomed to travelling we have a tolerable clear conception of a *hundred*, and even of a *thousand* miles; but we have no clear nor adequate conception of a body, or of a portion of space, ten hundred thousand, ten hundred millions, or ten hundred billions of miles in extent. The mind, however, may be assisted in its conceptions, and in its comparative estimate of different numbers, by fixing on some particular number as a standard. If, according to the common reckoning, we suppose, that 5828 years have elapsed since the commencement of time, the number of seconds, or moments, in this period, will amount to 183,913,782,212, or one hundred and eighty-three thousand, nine hundred and thirteen millions, seven hundred and eighty-two thousand, two hundred and twelve, which is less than a fifth part of a billion. If the distance of the nearest stars from the earth be at least twenty billions of miles, then this distance may be otherwise expressed by saying, that the number of miles which intervene between us and these bodies is more than a *hundred times greater* than the number of moments which have elapsed since the creation; and, by a similar comparison, it will be found, that the number of cubical miles within the limits of the planetary system, is 132,000,000,000,000,000, or, one hundred and thirty-two thousand billions of times greater than the number of moments in 5828 years.

It has been computed, that the earth, supposing it a solid globe, contains about 30,000,000,000 000,000,000,000,000,000,000, or thirty quintillions of grains of sand, supposing a hundred grains of sand to be equal in length to an inch, and, consequently, a million of such grains for every cubical inch. If we use this number as a standard for estimating the number of *cubical* miles contained within the space which intervenes between us and the nearest stars, we shall find that the number of *cubical miles* comprehended within this space is more than ten thousand millions of times greater than the number of the grains of sand contained in the globe on which we dwell.

Though the human mind can form no definite conception of such numbers and magnitudes, yet it may be useful occasionally to reflect on such subjects; as it is the only, or at least the principal mode by which limited minds like ours can approximate to an idea of the *infinity* of the Creator; and if an image of infinity is presented to the mind in the spaces comprehended within the limits of our system, how overpowering the conception of innumerable systems, to which ours bears no more proportion than a drop of water to the mighty ocean! How ineffably glorious must be the attributes of that Incomprehensible Being who pervades every part of this vast universe, and who continually superintends all its minute and diversified movements!

NOTE IV, p. 282.—*On the Means by which it may Probably be Ascertained whether the Moon be a Habitable World.*

About the year 1818, the Author published, in the Monthly Magazine, a few observations on the surface of the Moon, in which a few remarks were offered on this subject. The following is an extract from that communication:—

"If we be ever to obtain an ocular demonstration of the habitability of any of the celestial orbs, the Moon is the only one where we can expect to trace, by our telescopes, indications of the agency of sentient or intelligent beings; and I am pretty much convinced, that a long-continued series of observations on this planet, by a number of individuals in different places, might completely set at rest the question, 'Whether the Moon be a habitable world.' Were a vast number of persons, in different parts of the world, to devote themselves to a particular survey of the Moon—were different portions of her surface allotted to different individuals, as the object of their particu-

lar research—were every mountain, hill, cavern, cliff, and plain, accurately inspected—and every change and modification in the appearance of particular spots carefully marked and represented in a series of delineations, it might lead to some certain conclusions, both as to her physical constitution, and her ultimate destination. It can be demonstrated, that a telescope which magnifies 100 times, will show a spot on the Moon's surface, whose diameter is 1223 yards; and one which magnifies 1000 times, will, of course, enable us to perceive a portion of her surface, whose size is only 122 yards; and, consequently, an object, whether natural or artificial, of no greater extent than one of our large edifices, (such as St. Paul's Cathedral, London,) may, by such an instrument, be easily distinguished. Now, if every minute point on the lunar surface were accurately marked by numerous observers, it might be ascertained whether any changes are taking place, either from physical causes, or from the operations of intelligent agents. If a large forest were cutting down —if a city were building in an open plain, or extending its former boundaries —if a barren waste were changing into a scene of vegetation—or, if an immense concourse of animated beings were occasionally assembled on a particular spot, or shifting from one place to another—such changes would be indicated by certain modifications of shade, colour, or motion; and, consequently, would furnish a direct proof of the agency of intelligent beings analogous to man, and of the Moon being a habitable globe. For although we may never be able to distinguish the *inhabitants* of the Moon (if any exist), yet if we can trace those *effects* which can flow only from the operations of intelligent agents, it would form a complete demonstration of their existence, on the same ground on which a navigator concludes an unknown island to be inhabited, when he perceives human habitations and cultivated fields.

"That changes occasionally happen on the lunar hemisphere, next the earth, appears from the observations of Herschel and Schroeter, particularly from those of the latter. In the Transactions of the Society of Natural Philosophy at Berlin, Schroeter relates, that, on the 30th December, 1791, at five o'clock, *p.m.*, with a seven-feet reflector, magnifying 161 times, he perceived the commencement of a small crater on the south west declivity of the volcanic mountain in the *Mare Crisium*, having a shadow of at least 2''·5. On the 11th January, at twenty minutes past five, on looking at this place again, he could see neither the new crater nor its shadow. Again, on the 4th January, 1792, he perceived, in the eastern crater of Helicon, a central mountain, of a clear grey colour, 3'' in diameter, of which, during many years' observations, he had perceived no trace. 'This appearance,' he adds, 'is remarkable, as probably from the time of Hevelius, the western part of Helicon has been forming into its present shape, and Nature seems, in that district, to be particularly active.'—In making such minute observations as those to which I allude, it would be proper, along with an inspection of the Moon's luminous disk, to mark the appearances of different portions of her dark hemisphere, when it is partially enlightened by the reflected light from the earth, soon after the appearance of new moon. These researches would require a *long-continued* series of the most minute observations, by numerous observers in different regions of the globe, which could be effected only by exciting, among the bulk of mankind, a general attention to such investigations. But were this object accomplished, and were numerous observations made from the tops of mountains, and in the serene sky of southern climes, where the powers of the telescope are not counteracted by dense vapours, there can be little doubt that direct proofs would be obtained, that the Moon is a habitable world; or, at least, that the question in relation to this point would be completely set at rest."

NOTE V.—*Remarks on the pretended discovery of a Lunar Fortification.*

The British public, some years since, was amused by the announcement of a discovery said to have been made by Professor Frauenhofer of Munich.

This gentleman was said to have discovered a *fortification* in the Moon, and to have distinguished several lines of roads, supposed to be the work of the lunar inhabitants. It is scarcely necessary to say, that such announcements are obviously premature. To perceive distinctly in the Moon the shape of an object which resembles a fortification, it is requisite, that that object be of a much larger size than our terrestrial ramparts. Besides, although an object resembling one of our fortifications were perceived on the surface of the Moon there would be no reason to conclude, that it served the same purpose as fortifications do among us. We are so much accustomed to war in our terrestrial system, and reflect so little on its diabolical nature, that we are apt to imagine that it must form a necessary employment even in other worlds. To be assured that a fortification existed in the Moon for the same purposes as with us, would indeed be dismal tidings from another world; for it would be a necessary conclusion, from such intelligence, that the inhabitants of that globe are actuated by the same principles of depravity, ambition, and revenge, which have infected the moral atmosphere of our sublunary world. With regard to the pretended discovery of the lunar *roads*, it may not be improper to remark, that such roads need to have been at least 400 feet broad, or ten times the breadth of ours, in order to be perceived as faint lines through a telescope which magnifies a thousand times; which is a higher power, I presume, than Frauenhofer can apply with *distinctness* to any of his telescopes. It is not at all likely that the lunar inhabitants are of such a gigantic size, or employ carriages of such an enormous bulk, as to require roads of such dimensions, since the whole surface of the Moon is only the thirteenth part of the area of our globe.

Schroeter conjectures the existence of a great city to the north of *Marius* (a spot on the Moon), and of an extensive canal towards *Hygena*, (another spot), and he represents part of the spot named *Mare Imbrium*, to be as fertile as the Campania. Similar remarks to those now stated will apply to these conjectures of Schroeter. We are too apt to imagine, that the objects we perceive in the Moon must bear a certain resemblance to those with which we are acquainted on the Earth; whereas there is every reason to believe, from the variety we perceive in nature, that not one world resembles another, except in some of its more prominent and *general* arrangements. The Moon bears a general resemblance to the Earth, in its being diversified with mountains and valleys; but the positions and arrangement of these objects in the Moon, and the scenery they exhibit, are materially different from what appears on the surface of the terraqueous globe.

Note VI, p. 337.—*On a Plurality of Worlds.*

The doctrine of a plurality of worlds is now admitted as highly probable, both by philosophers and by enlightened divines. But it has been admitted by many persons on grounds that are too general and vague, and, consequently, a *full conviction* of its truth is seldom produced in the mind. In different parts of the preceding volume I have all along taken it for granted, because I consider it as susceptible of a *moral demonstration.*—The following heads of argument, were they fully illustrated, would go far to carry demonstration to the mind on this subject; namely, That there are numerous bodies in the universe of a bulk sufficient to contain myriads of intelligent beings, and to afford them enjoyment—that there appears, in the constitution of many of these bodies, a variety of arrangements evidently adapted to this end—that, in relation to the planets of our system, there are many circumstances which bear a striking resemblance to the constitution of our globe and its appendages. They have annual and diurnal motions, moons, atmospheres, mountains, and vales—that light and heat and colour appear to be distributed throughout the regions of immensity; and that these agents can have a relation only to the necessities and the happiness of organized intelligencies—that

every part of nature, so far as our observations on the surface of this globe extend, appears to exist solely for the sake of sentient beings—that this doctrine is more worthy of the Infinite Creator, and gives us a more glorious and magnificent idea of his nature, than to suppose his benevolent regards confined to the globe on which we dwell. When these and a variety of other arguments are considered, in connection with the *Wisdom* and other attributes of the Deity, they amount not only to a high degree of probability, but to something approaching to a moral demonstration. But to illustrate these arguments in minute detail, so as to make a convincing impression on the mind, would require a volume of a considerable size. There is no work in our language, which takes an extensive view of this subject, in connection with the attributes of Deity and the intimations contained in Divine Revelation. Fontenelle's 'Plurality of Worlds,' contain a number of ingenious reasonings; but he treats the subject in too light and flippant a manner, and without the least reference to a Supreme Intelligence. The celebrated Huygens, in his '*Cosmotheoros*,' instead of attempting to prove the doctrine of a plurality of worlds, takes it for granted, and indulges chiefly in conjectures respecting the organical structure and faculties of their inhabitants.[1]

That the Scriptures are silent on this head, has been assumed by some as a presumptive argument that this doctrine is without solid foundation. I have already endeavoured to show that this assumption is unfounded. A plurality of worlds is more than once asserted in Scripture, and in numerous passages is evidently taken for granted. Celestial intelligencies are represented as ascribing "glory, honour, wisdom, and power" to the King of heaven, "because he hath created all things, and because they perceive his works to be 'great and marvellous.'" But if all the great globes in the firmament were only so many frightful deserts, destitute of inhabitants, such a universe could never inspire superior intelligencies with admiration of the *wisdom* of the Creator. For wisdom consists in proportioning *means* to *ends*; but, in the case supposed, there would be no proportion between the means and the end. The means are indeed great and astonishing; but no end appears to justify such a display of creating energy.—The Psalmist, when he contemplated the heavens, was so affected with the idea of the immense population of the universe, that he seems to have been almost afraid lest he should be overlooked amidst the immensity of beings that are under the superintendence of God: "When I consider thy heavens—what is man that thou art mindful of him!" There would be no propriety nor emphasis in this exclamation, if the heavenly orbs were devoid of inhabitants; for, if no intelligent beings exist besides man, and a colony of angels, it would not appear wonderful that the Creator should exercise a particular care over the one half of his intelligent offspring. But if we conceive the universe as composed of ten thousand times ten thousand worlds peopled with myriads of intellectual beings of various orders, the sentiment of admiration implied in the passage is extremely natural and emphatic, and conveys to us an impressive idea of the Intelligence, the Benificence and the Condescension of the Founder and Governor of all worlds.

NOTE VII, p. 423.—*The Daguerreotype.*

Photographs, or sun pictures, have hitherto been produced in neutral colours which exhibit merely the gradations of light and shade. It has frequently, however, been stated that processes whereby objects may be shown in their *natural colours*, have been discovered. Some years since, M. Isenrig, a painter of Munich, was said to have patented some such discovery; and now again (1856) we hear of an American artist who is about to produce a revolution in

1 Since the first editions of this work were published, the author has fully illustrated the topics above stated, together with other kindred subjects, in his volumes entitled 'Celestial Scenery,' and 'The Sidereal Heavens,' which are embellished with numerous engravings.

the photographic art, and make his own fortune at the same time. No reliable information has, however, yet been received of his discovery. In all the various photographic processes that have arisen since the discovery of M. Daguerre, the colouring has been a mechanical operation independent of the Camera.

NOTE VIII, p. 452.—*Electro-Magnetic Machines.*

The possibility of moving small pieces of mechanism by the action of the electro-magnetic power has been known for some time past, but it seems never to have been practically applied on a large scale till in 1837 it was adapted to the propulsion of a boat on the river Neva, by Professor Jacobi of Petersburgh. On the 25th September, 1838, a galley, 28 feet in length and 7¼ in breadth, was provided with paddles similar to those of a steam vessel. The action was produced from 320 pair of plates arranged along the sides of the galley, room being left for twelve persons. The vessel was made to proceed against the stream, and the speed attained in still water was three English miles per hour. The plan consisted in rapidly reversing the poles during the action.—Since then a machine has been contrived by Mr. R. Davidson of Aberdeen, in which a reiterated series of attractions are employed to produce the effect. Mr. Davidson has made an arrangement by which, with only two electro-magnets, and less than one square foot of zinc surface (the negative metal being copper), a lathe is driven with such velocity, as to be capable of turning small articles. He has another arrangement by which, with the same small extent of galvanic power, a small carriage is driven, on which two persons are carried along the floor of a room. The machines are simple, and easily manageable. It was at first supposed that a very great power, in no degree inferior even to that of steam, but much more manageable, much less expensive, and occupying greatly less space—if the coals be taken into account—had been obtained. The difference between Professor Jacobi's plan and Mr. Davidson's is this; that Jacobi produces motion by changing the poles of the magnets, and Mr. Davidson, by cutting off the galvanic current at given points—the power of alternating as the rotation proceeds, from a neutralized magnet to a newly changed one. In both experiments it was demonstrated that the power of the magnet is increased, by increasing the diameter, and adding to the length of the helix. The power is also increased by increasing the size of the bars. Neither of these machines have, however, proved of practical utility. Many means of driving locomotives other than by steam are known, but the motive power has in all cases proved considerably more expensive than the generation of steam by coal.

NOTE IX, p. 419.—*On Telescopes; with a brief notice of a* NEW REFLECTING TELESCOPE, *constructed by the Author.*

Though the highest magnifying power of Sir W. Herschel's large telescope, which is now dismantled, was estimated at six thousand times, yet it does not appear that he ever applied this power with success, when viewing the moon and the planets. The deficiency of light, when using so high a power, would render the view of these objects less satisfactory than when viewed with a power of only a thousand times. Still, it is quite certain, that if any portions of the moon's surface were viewed through an instrument of such a power, they would appear as *large* (but *not nearly so bright and distinct*) as if we were placed about 40 miles distant from that body. The enlargement of the angle of vision, in this case, or the apparent distance at which the moon would be contemplated, is found by dividing the moon's distance—240,000 miles, by 6000, the magnifying power of the telescope, which produces a quotient of 40—the number of miles at which the moon would appear to be placed from the eye of the observer. Sir W. Herschel appears to have used the

highest powers of his telescopes only, or chiefly, when viewing some very minute objects in the region of the stars. The powers he generally used, and with which he made most of his discoveries, were 227,460,754,932, and occasionally 2010,3168, and 6450, for the purpose of making experiments of their effect on double stars, etc.

It is doubtful to what particular individual we owe the invention of the telescope. Some have supposed that Roger Bacon and Baptista Porta invented this instrument. Borelli ascribes the invention to Zacharias Jansen, a native of Middleburg. Perhaps the account given in the article to which this note refers, and which is stated by a variety of authors, may be as probable as any other. It is certain the telescope was not in general use until the beginning of the 17th century, and that no discoveries in the heavens were made with it till the year 1609.

There are two kinds of telescopes, *Refracting* and *Reflecting*. In refracting telescopes, the rays of light pass through convex or concave glasses or lenses. The object-glass is always convex, and forms an image or picture of the object in an inverted position in its focus, which image is viewed by the eye-glass; and the magnifying power is in the proportion of the focal distance of the object-glass to that of the eye-glass. The focal distance of a convex glass may be ascertained by holding it in the rays of the sun, opposite to a piece of white paper, and measuring the distance between the glass and the white spot, or burning point, formed on the paper. An astronomical telescope for viewing celestial objects may be constructed with only two glasses. If an object-glass, thirty inches focal distance, be fixed in the end of a tube, and an eye-glass of one inch focus be placed at the other end, at the distance of thirty-one inches from the object-glass, a telescope will be formed which will magnify in the proportion of one to thirty, or thirty times; that is, objects seen through such a telescope will appear thirty times larger in diameter, or thirty times nearer than to the naked eye. By such an instrument, the inequalities on the Moon's surface, and some of the satellites of Jupiter, may be perceived; but when directed to land objects, they will appear inverted or turned upside down. In order to reverse the appearance of the object, two other eye-glasses are required;—or, if a *concave* eye-glass of a similar focus be placed at twenty-nine inches from the object-glass, the object will appear in its natural position, and the magnifying power will be the same; but the field of view will be much smaller. Astronomical telescopes of this construction were formerly made of 120, and even of 200 feet in length, and were used without a tube; the object-glass being placed on the top of a long pole; but these are now entirely superseded by achromatic telescopes. In the achromatic telescope, the object-glass is compounded of two, and sometimes of three lenses, placed close to each other, one of which is a double concave of white flint glass, and the other a double convex of crown glass. By this means an image is formed without being blended with the prismatic colours; and it will therefore bear a large aperture, and a much greater magnifying power, than a common refractor. A good achromatic telescope four feet long will magnify objects as much as a common refractor 100 feet long.

In *Reflecting* telescopes the images of objects are formed by speculums or mirrors, instead of lenses. They are of two kinds, the *Gregorian* and the *Newtonian*. The Gregorian reflector consists of a tube in which a concave mirror, having a hole in its centre, is placed. The rays of light from distant objects falling upon this mirror, form an image before it, in its centre or focus. This image is intercepted by a smaller concave mirror, which reflects it back, through the hole in the large mirror to an eye-glass, through which the observer views the object. In the Newtonian Reflector, a plane mirror, placed at an angle of 45 degrees, is substituded in place of the small mirror, in the Gregorian construction, and the observer looks upon the object through the side of the tube. Sir David Brewster has suggested an interesting improvement in the construction of this instrument, which is described in the *Edin. Encyc.* Art. *Optics*.

New Reflector.—Several years ago, the Author commenced a series of experiments on Reflecting Telescopes; and has lately constructed several on a new plan and principle. In this construction there is no *small* speculum, either plane, convex, or concave; there is no tube, except a short one of two or three inches in length, for holding the speculum. The observer sits with his back to the object, and views the image formed by the speculum through an eye-piece, which requires to be nicely directed and adjusted. Three or four instruments of this construction have been fitted up, with specula of 16, 28, 35, and 49 inches focal distance. One of them having a speculum of eight inches focus, and two inches diameter, with a terrestrial eye-piece, magnifying about twenty-five times, forms an excellent parlour telescope for viewing land-objects, and exhibits them in a brilliant and novel aspect. When compared with a Gregorian of the same size and magnifying power, the quantity of light upon the object appears nearly doubled, and the image is *equally distinct.* It represents objects in their natural colours, without that dingy and yellowish tinge which appears when looking through a Gregorian. Another of these instruments, having a speculum of twenty-eight inches focal distance, and an eye-piece producing a magnifying power of about 100 times, serves as an excellent astronomical telescope. By this instrument the belts and satellites of Jupiter, the ring of Saturn, and the mountains and cavities of the Moon, may be contemplated with great ease and distinctness. By placing the pedestal on the floor of the apartment, when the object is at a high elevation, we can view celestial phenomena with the same ease as if we were sitting at a writing-desk reading a book. With a magnifying power of about forty times applied to this telescope, terrestrial objects appear extremely bright and well defined. A speculum of forty-nine inches focal distance, and six and a half inches diameter, has lately been fitted up on the same principle. With magnifying powers of from 100 to 130 times it exhibits distinct and interesting views of the Moon's surface and of the ring of Saturn, and with a power of fifty-six times it affords a beautiful view of land objects. The specula used in some of these instruments are far from being good; being of a yellowish colour, and scarcely half polished, and having large holes in the centre; as they were originally intended for Gregorian reflectors; yet the brightness of vision approaches nearly to that of Achromatic Telescopes. The experiments which have been made on this subject demonstrate, that a *tube* is not necessary for a reflecting Telescope, when viewing either celestial or terrestrial objects; and, therefore, this construction of the instrument may be denominated, The Aerial Reflector.

In the system of Optics, lately published in the Edinburgh Encyclopedia, (one of the most luminous and comprehensive treatises which has yet appeared on this subject,) the writer in his introduction to the account of Sir D. Brewster's improvement on the Newtonian Telescope, remarks:—"If we could dispense with the use of the small specula in telescopes of modern length, by inclining the great speculum, and using an oblique, and consequently a *distorted* reflection, as proposed first by La Maire, we should consider the Newtonian Telescope as perfect, and, on a large scale, or when the instrument exceeds twenty feet, it has undoubtedly this character, as nothing can be more simple than to magnify, by a single eye-glass, the image formed by a single speculum.—As the *front view* is quite *impracticable*, and indeed *has never been attempted* in instruments of a small size, it becomes of great practical consequence to remove as much as possible the evils which arise from the use of a small speculum," etc. The instruments noticed above have effectuated the desirable object alluded to; and the principle of the construction is neither that of Sir W. Herschel's *front view*, nor does it coincide with that proposed by La Maire, which seems to be a mere hint which never was put into execution.

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